Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

1010 EMPIRE BUILDING | October, 1943 | PITTSBURGH, PA.

MESTA Plate Mills

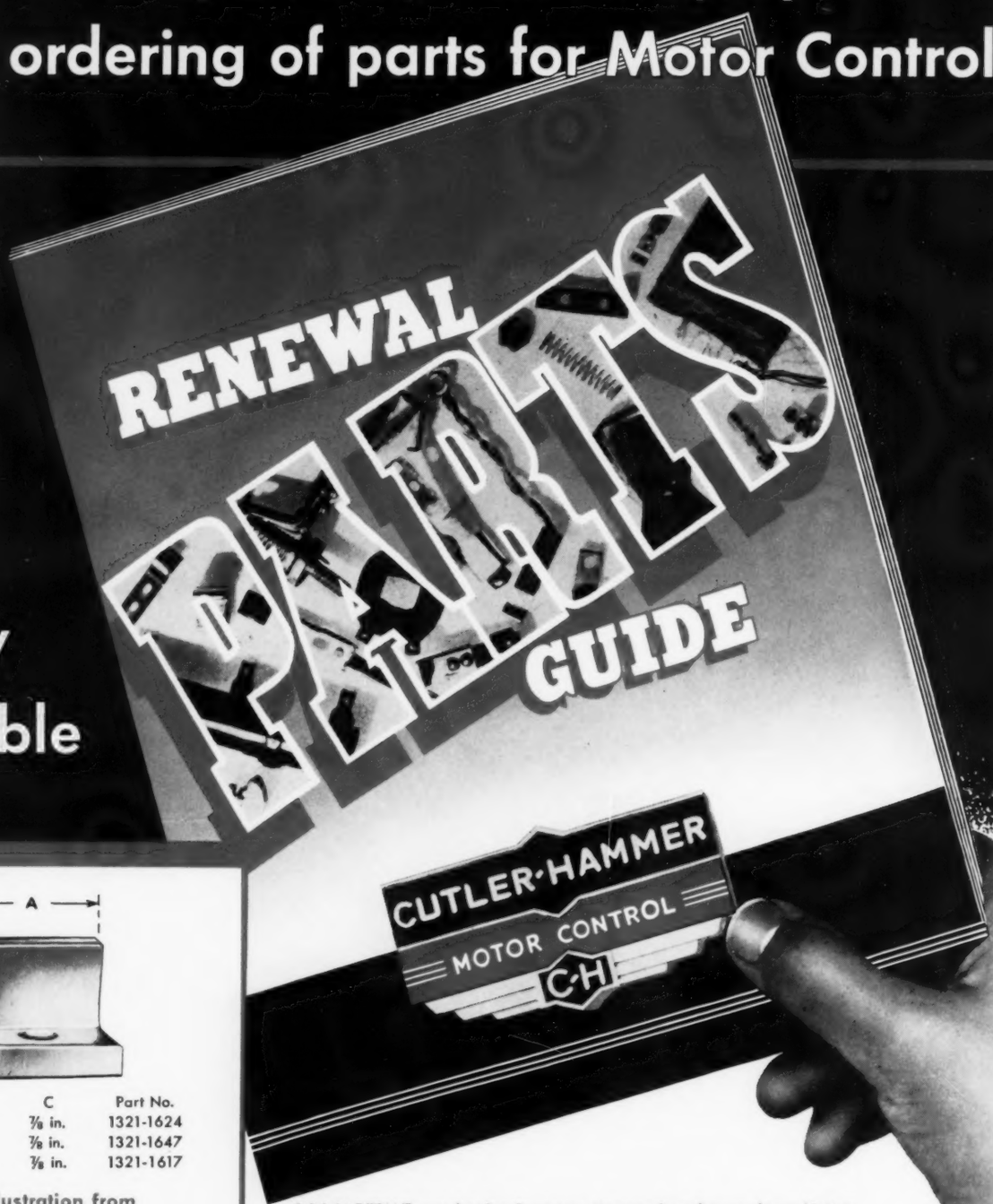
140" FOUR HIGH
REVERSING PLATE MILL
DESIGNED AND BUILT BY MESTA

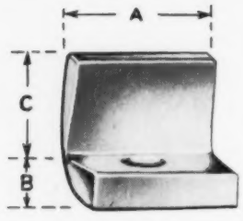
The Army-Navy "E" flag with four stars, flies over the Mesta Plant.

MESTA MACHINE COMPANY • PITTSBURGH, PA.

To speed up and simplify the ordering of parts for Motor Control

Free Timely Valuable





A	B	C	Part No.
½ in.	⅞ in.	⅞ in.	1321-1624
¾ in.	⅞ in.	⅞ in.	1321-1647
1 in.	⅞ in.	⅞ in.	1321-1617

Typical Illustration from the Renewal Parts Guide

Each part is shown in "lifelike" perspective so it can be easily matched up with the part to be replaced. Full dimensions are given to assure accurate part order number.

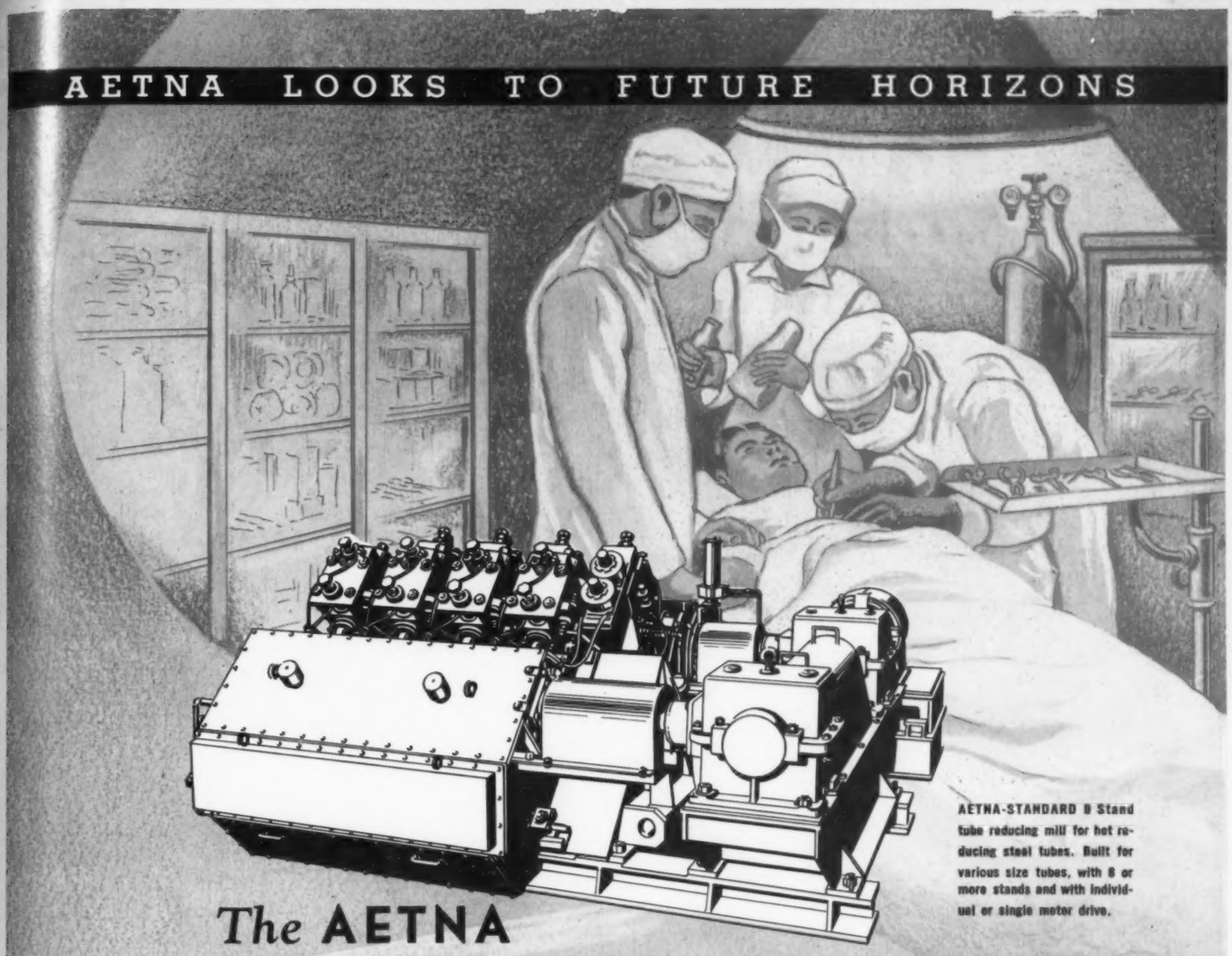
CUTLER·HAMMER
MOTOR CONTROL
C·H

WARTIME production imposes staggering demands on Motor Control and the men who keep it going. Thus the job of ordering renewal parts must be reduced to its simplest terms. This is just what the new Cutler-Hammer Renewal Parts Guide does for you.

It illustrates standard C-H parts, with dimensions, so clearly anyone can easily identify the parts needed and order them by the correct parts number. This short-cut guide is a boon to busy maintenance men. It helps eliminate errors in ordering and avoids delays in delivery...insures having correct parts at hand. Moreover, it includes many practical maintenance ideas for prolonging the life of controllers, resistors, magnets, brakes and clutches.

Write for your copy at once. It's FREE when requested on your business letterhead. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

AETNA LOOKS TO FUTURE HORIZONS



AETNA-STANDARD 9 Stand tube reducing mill for hot reducing steel tubes. Built for various size tubes, with 8 or more stands and with individual or single motor drive.

The AETNA HOT TUBE REDUCING MILL

TODAY these mills, in many different plants, are hot reducing steel tubes that may be used in cooling and air-conditioning units for use in military hospital operating rooms, refrigerating vital medicines and plasmas and helping to keep America's wounded comfortable.

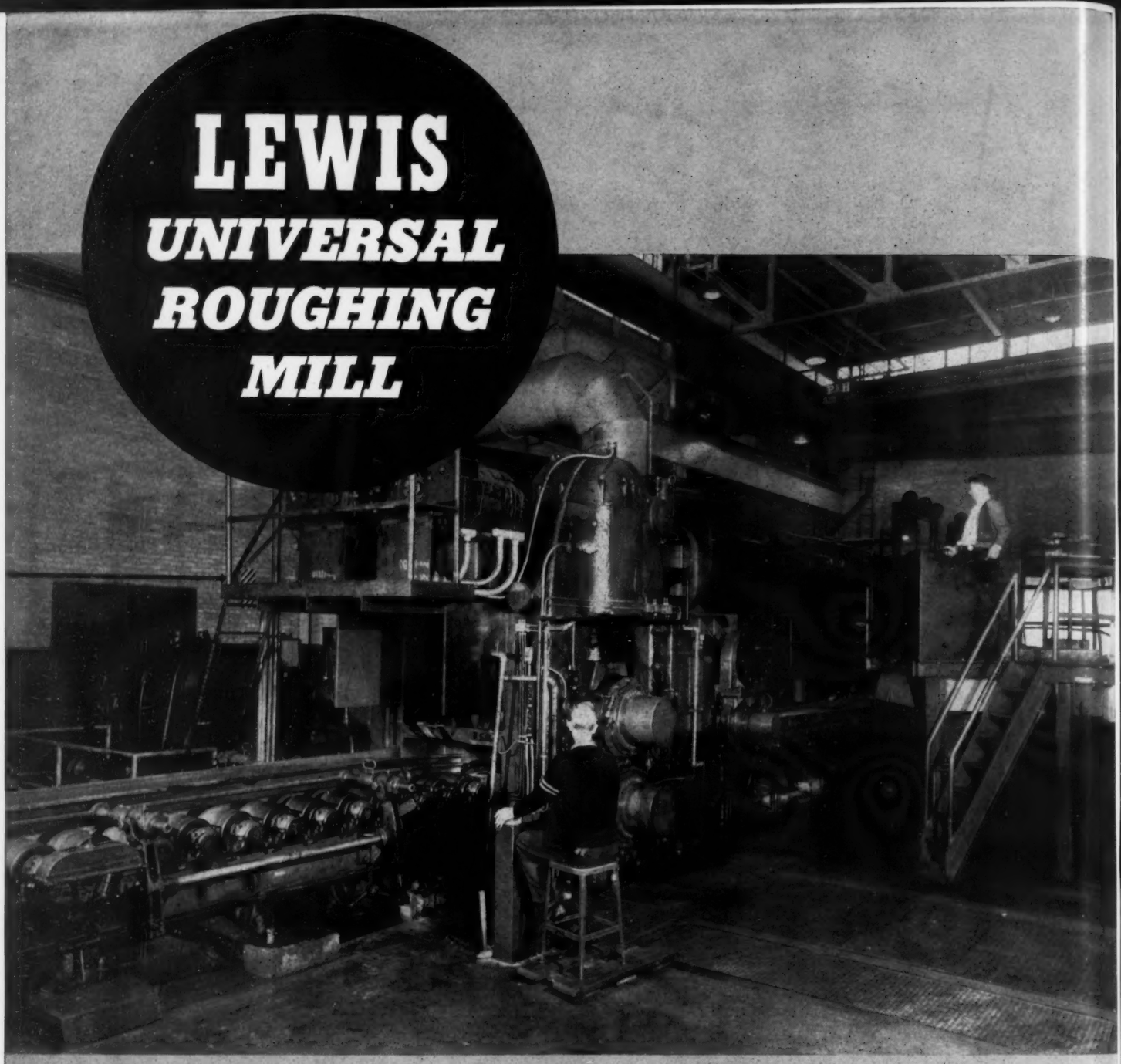
TOMORROW in the post-war world these same mills may be producing tubing for individual units for the streamlined home of the future. Fast frozen food the year around at your fingertips, air conditioning for every room; these will be among the comforts achieved tomorrow from the experience we gain today.

The AETNA-STANDARD ENGINEERING COMPANY
YOUNGSTOWN · OHIO · U.S.A.
ARMY E NAVY

DESIGNERS AND BUILDERS TO THE STEEL, NON-FERROUS AND CHEMICAL INDUSTRIES

ASSOCIATED COMPANIES:
HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

LEWIS
UNIVERSAL ROUGHING MILL



This Universal Roughing Mill for non-ferrous materials is equipped with independent drive on the vertical rolls.

It is exceeding all expectations in producing products for the war program.

Let Lewis Rolls and Rolling mill machinery help you speed up production for victory.

ARMY E NAVY

LEWIS
Rolls and Rolling Mill Machinery step up tonnage

LEWIS FOUNDRY & MACHINE
DIVISION OF BLAW-KNOX CO.
PITTSBURGH, PA.

TECHNOLOGY DEPT.

Let the Industry speak of our design ...

REYNOLDS METALS COMPANY
INCORPORATED
FEDERAL RESERVE BANK BUILDING
RICHMOND-VIRGINIA

2500 SOUTH THIRD STREET
LOUISVILLE, KY.

December 17, 1941

Hydropress, Incorporated
277 Madison Avenue
New York, New York

Gentlemen:

I believe you would like to have an expression from us on the 2200 ton horizontal extrusion press which you have supplied for our new plant at Louisville and which, although in operation but a short time, has established itself as being very flexible and efficient.

We have produced tubing as well as solid shapes and bar and have pierced solid billets of hard alloys from which we obtained concentric tubes of the best quality which can be desired.

Our opinion is to the effect that the press is excellently engineered, both from the standpoint of design and workmanship, and in our opinion is the most efficient now available on the market.

Sincerely yours,

J. P. Macauley

J. P. Macauley
Vice President
REYNOLDS METALS COMPANY

HYDROPRESS · INC.
ENGINEERS CONTRACTORS
HYDRAULIC PRESSES · ROLLING MILLS
PUMPS · ACCUMULATORS
570 LEXINGTON AVENUE · NEW YORK · N. Y.

*NEUTRALIZATION

DEFINITION: The neutralization number is the weight in milligrams of the amount of potassium hydroxide (KOH) required to neutralize the acid constituents in one gram of oil.

NEUTRALIZATION TEST: Following a carefully prescribed procedure, a definite quantity of oil together with a mixture consisting of equal parts distilled water and alcohol are agitated thoroughly and heated to boiling. A phenolphthalein indicator is added and a solution of aqueous potassium hydroxide of definite strength is poured into the mixture in small increments and shaken vigorously each time. The first appearance of a sharp pink color throughout the alcohol water layer indicates the point of complete neutralization.

The number of milligrams of potassium hydroxide per gram of oil required to achieve this result is called the Neutralization Number.

SIGNIFICANCE: Corrosive mineral acids are sometimes used during the refining process of certain crudes. As a precaution against their presence in harmful proportions, it is customary to specify a maximum Neutralization Number of 0.10 for clear colored, straight mineral lubricating oils.

The Neutralization Number has no such significance in connection with unfiltered cylinder oils and black oils. These may contain larger amounts of harmless organic acids originating in the crude petroleum. High Neutralization Numbers do not imply corrosive acidity with compounded oils; i.e. mixtures of mineral oils and fatty oils. The latter oils are often inherently high in organic acidity.

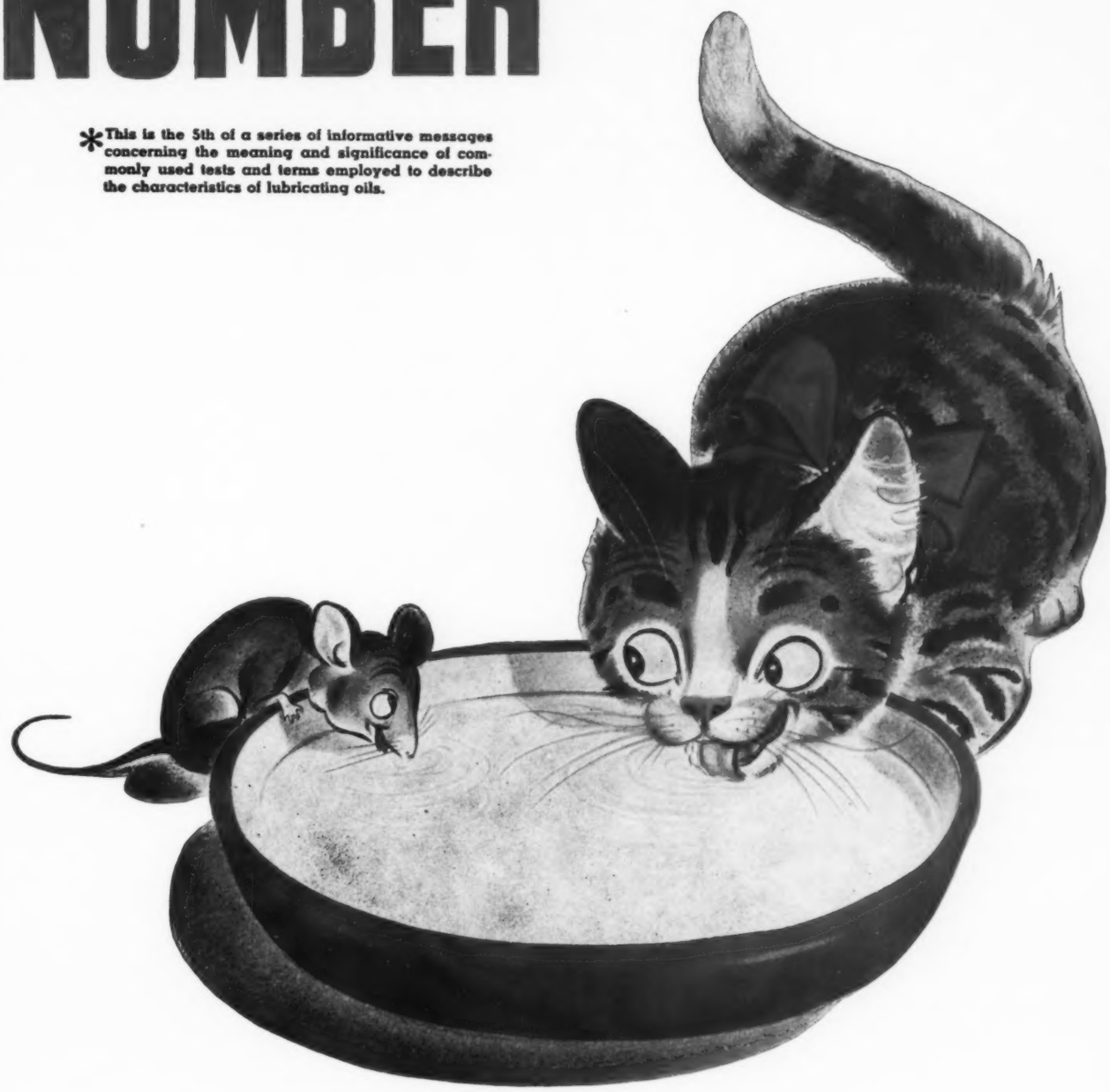
INDUSTRIAL TYCOL OILS-GREASES

DRUMS! DRUMS! DRUMS!
War needs make it extremely important that all empty drums be returned immediately.

SCIENTIFICALLY ENGINEERED FOR EVERY INDUSTRIAL USE **TYCOL**

NUMBER

*This is the 5th of a series of informative messages concerning the meaning and significance of commonly used tests and terms employed to describe the characteristics of lubricating oils.



Tycol lubricants are manufactured in a comprehensive line so as to meet every specific operating requirement. Whether straight mineral or compounded, they are produced under rigid control to assure freedom from all harmful acidity.

Tide Water Engineers will recommend the Tycol lubricant best suited to your particular requirements.

TIDE WATER ASSOCIATED OIL COMPANY

Eastern Division: 17 Battery Place, New York 4, N. Y. • *Principal Branch Offices:* Boston, Philadelphia, Pittsburgh, Charlotte, N. C.

MAKERS OF THE FAMOUS VEEDOL MOTOR OIL

INDUSTRIAL LUBRICANTS

The welded construction of Cleveland Cranes gives them great rigidity that is immediately noticeable by experienced crane operators. They ride smooth and easy with very little vibration.
Hundreds of Clevelands like this 10 ton, 100 foot span crane are serving the steel industry.

THE CLEVELAND CRANE & ENGINEERING CO.

1131 EAST 283 RD ST. WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

A RECORD attendance of 2100 marked the Annual Engineering Conference in Pittsburgh last month. Particularly noticeable was the greatly increased attendance at the technical sessions.

▲

A STATEMENT made by Wilfred Sykes in his talk at the Annual Conference dinner gives considerable food for thought. Mr. Sykes said that 75 million tons of our annual ingot capacity (which should reach 94 million) would be economically competitive in the post-war period. Place your bets, gentlemen.

▲

THE Iron and Steel Daily News for September 28th, the first day of the Annual Engineering Conference, carried first published announcement of remanning tables, a link between the manning tables and the training programs. Remanning tables were originated, as were the manning tables, by Carnegie-Illinois Steel Corporation, and they may receive much the same national adoption by industry and manpower agencies.

▲

REMEMBER when we thought we would live up to those glowing predictions made for us in the high school yearbook?

▲

SEPTEMBER'S ingot tonnage of 7,488,978 is an all time high for a thirty day month, representing 100.4 per cent of capacity. For the first nine months of 1943, production totaled 66,294,032 tons, compared with 63,966,055 in the corresponding period of last year.

▲

SEPTEMBER also saw a new record for that month in iron ore shipments on the Great Lakes, when carriers hauled 12,742,821 tons down the lakes. The season's total to the end of September, however, is only 65,102,295 tons, compared with 72,441,453 tons in the corresponding period a year ago. This lag reflects the late start, accidents and inclement weather which have badgered the carriers this year. The Office of Defense Transportation has set the 1943 season goal at 86,500,000 tons as compared with last year's movement of 92,076,781 tons.

THOSE who remember "needled" beer and its dire effects can't help but wish the metallurgists had not adopted the term "needled" steels for those grades which are treated with boron, titanium, zirconium, etc., as substitutes for the richer alloys.

▲

WEIRTON Steel Company has made public the fact that they are rolling brass strip. Brass slabs are hot rolled down to about ½ in., then cold rolled on a tandem cold strip mill. Material must be skinned between the hot and cold rollings. Cleaning, annealing, and pickling complete the processing. Rolling operations required some modifications of usual steel rolling practice, but, as might be expected, the equipment was fully up to the task.

▲

A NEW five-year $2,500,000 research program announced by Bituminous Coal Research, Inc., includes 12 major research investigations involving over 90 specific topics. The work will cover almost every coal-consuming application, from domestic appliances to large industrial units, as well as a number of chemical uses, such as hydrogenation, synthetic rubber, etc.

▲

INDICATIVE of the expansion in the electric furnace field and of the great interest in this subject is the registration of more than 425 for the first meeting of the A. I. M. E. Electric Furnace Committee held in Pittsburgh, Pennsylvania, October 1-2.

▲

WELCOME news came to steel men in the announcements by J. T. Whiting, WPB Steel Division Chief, of simplification and reduction of report forms required from the industry, and by H. G. Batcheller, WPB Vice Chairman, of a decentralization of operations which will require fewer Washington visits as well as less paper work.

▲

THE joint meeting of the Chicago District and the Eastern States Blast Furnace and Coke Oven Associations, held in Cleveland October 15th with an attendance of approximately 300, brought out several interesting points. A survey of by-product coke ovens shows 48 per cent to be over 20 years old. To maintain our present capacity with ovens of an age usually found to be the active life, 1480 new by-product ovens must be constructed in the next few years.

The same report shows coking rates to range .66-1.07 in. per hr on 100 per cent high volatile coal, and .9-1.4 in. per hr with a high-low volatile mixture. Rates of .8-1.0 and 1.0-1.2 in. per hr, respectively, were recommended.

"Foyer" discussions mentioned the fact that coal washing in a number of plants had saved 10-31 cents per ton, with an average of 24 cents — also that new blast furnace linings had been satisfactorily dried out in 36 hr by using hot blast.

BONNOT-LENTZ • BILLETEER

BONNOT PRODUCTS

ENGINEERED FOR IMPROVED PRODUCTION

MORE TONNAGE-*with Monotonous Regularity*

● The BONNOT-LENTZ Billeteer feeds clean billets into mill schedules faster, at less cost and man hours than any other method.

● Production NOW and for all post-war civilian rehabilitation outlaws the high labor, tool, power and maintenance costs of hand chipping.

When those hard hitting steel salesmen return to the road, when fine quality steels are in demand for world reconstruction, what kind of competition will you have?

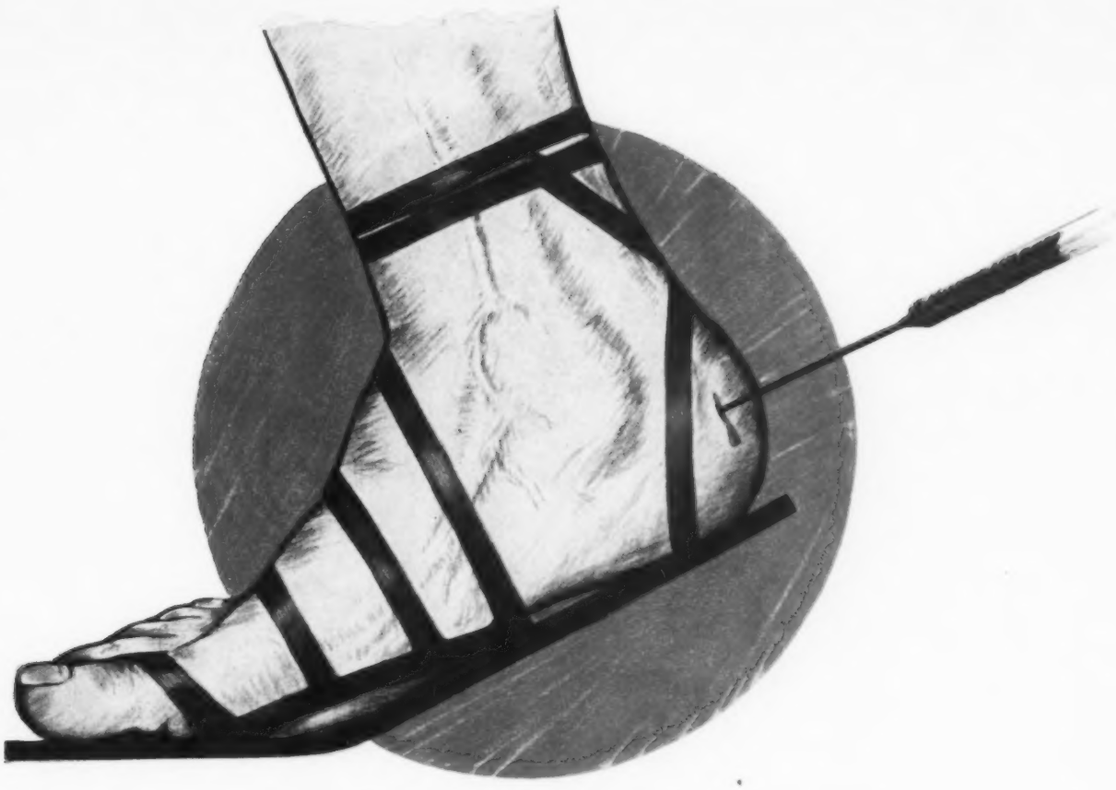
The Billeteer fits perfectly into any long range planning in addition to being a tonnage necessity now.

IF IT'S FACTS YOU WANT, HOW WOULD YOU LIKE TO TALK TO A PLANT WHICH HAS NINE BILLETEERS FEEDING STEEL INTO HIGH PRIORITIES?

THE BONNOT COMPANY, CANTON, OHIO

BONNOT

ENGINEERED FOR IMPROVED PRODUCTION



TAKING THE ACHILLES HEEL

OUT OF WAR PRODUCTION

Achilles, famed warrior of Greek mythology, was invulnerable save for a tiny spot on one heel. An arrow found this spot and killed him.

There must be no Achilles Heel in war industries. Even today's high production rate must be bettered. We can't afford to lose one production hour, not even one production minute.

Basic industries are continually increasing their output, thanks to man's will to win and to tried-and-true equipment. Thousands of plants rely upon Ingersoll-Rand compressors, turbo-blowers, pumps, hoists, pneumatic tools, and rock drills, knowing that they are dependable and efficient.

All plants of Ingersoll-Rand Company are flying the Army-Navy "E" awarded "for high achievement in the production of war materials."

Ingersoll-Rand

11 BROADWAY—NEW YORK, N. Y.

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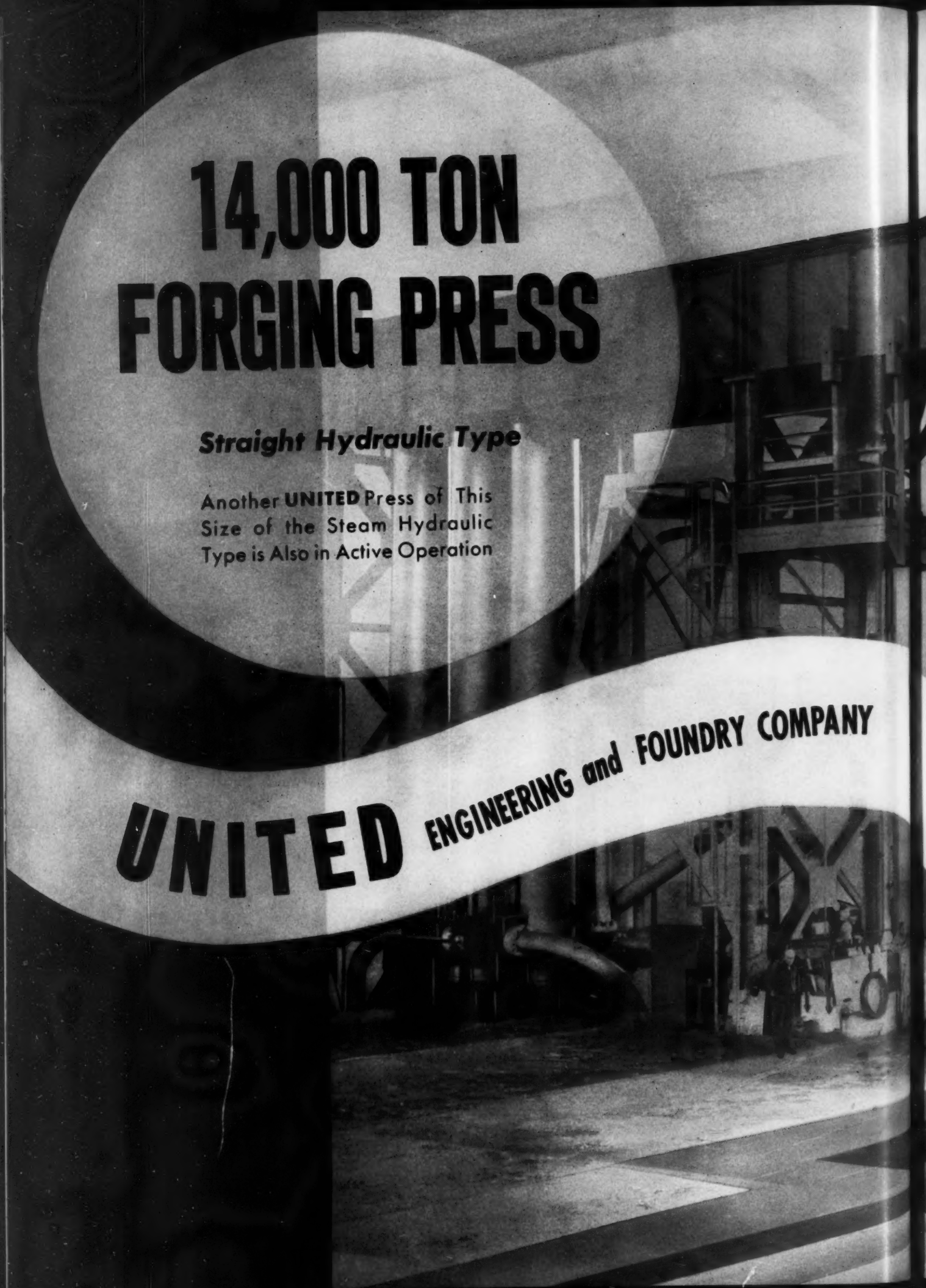
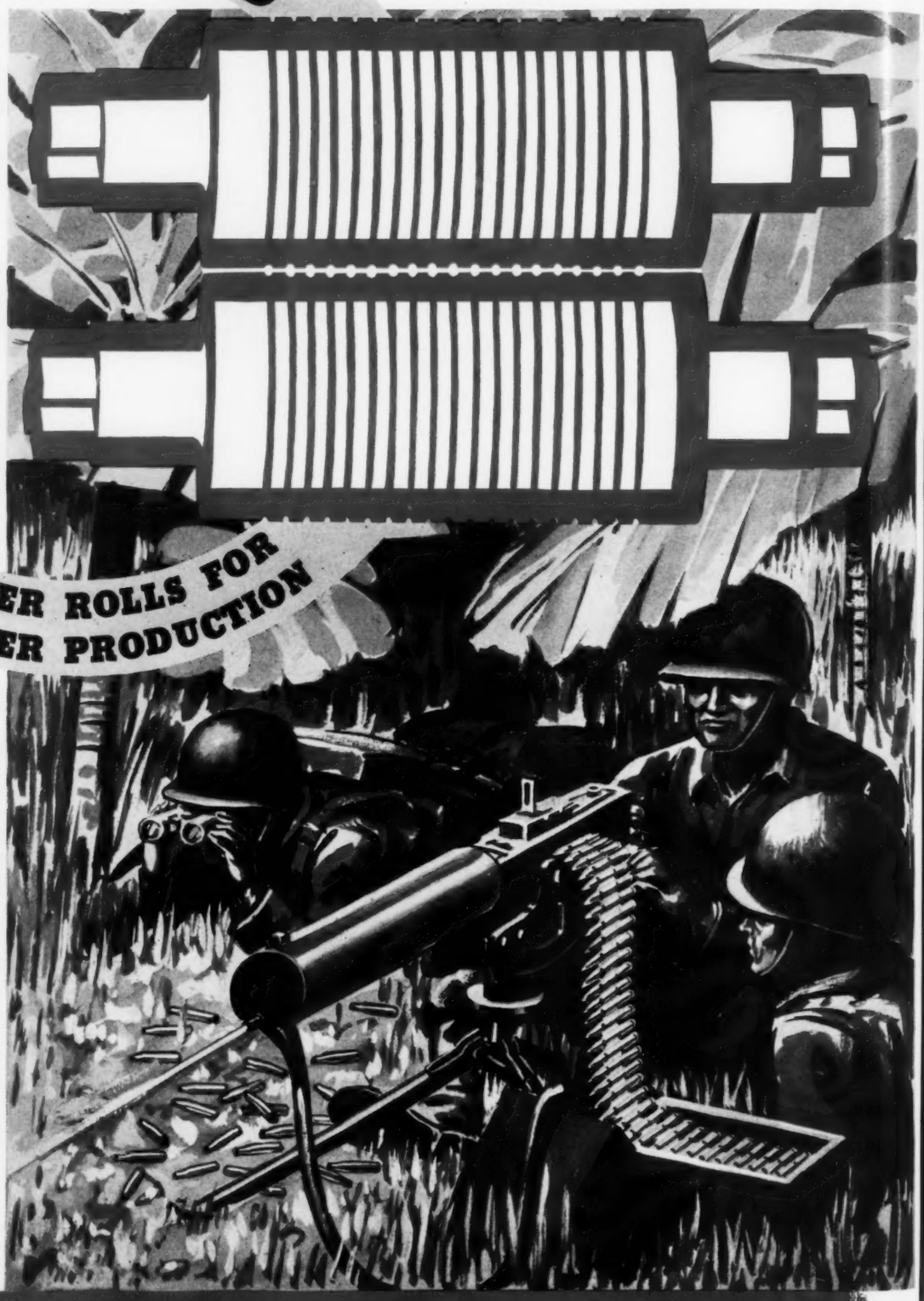
COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS


14,000 TON
FORGING PRESS
Straight Hydraulic Type
Another UNITED Press of This Size of the Steam Hydraulic Type is Also in Active Operation
UNITED ENGINEERING and FOUNDRY COMPANY

UNITED
UNITED
PITTSBURGH,
PA.

OUR JOB



BETTER ROLLS FOR GREATER PRODUCTION

Plan for victory and speed production with Pittsburgh Rolls — they are made for every rolling operation and every variety of mill.

PITTSBURGH ROLLS

PITTSBURGH ROLLS DIVISION of
BLAW-KNOX CO.—"Steel's Partner" • PITTSBURGH, PA.

The WEAN ENGINEERING COMPANY, Inc. • WARREN, OHIO

SPECIALISTS IN SHEET, TIN AND STRIP MILL EQUIPMENT

- HEAVY PLATE LEVELLERS
- HI-SPEED SHEET AND TIN MILL SHEAR LINES
- ELECTROLYTIC & BONDERIZING TIN PLATE EQUIPMENT
- WILSON TUBE ANNEALING FURNACES
- WEAN VACUUM CUP SHEET AND PLATE LIFTERS
- CONTINUOUS STRIP PICKLING, SLITTING, SIDE TRIMMING, AND RECOILING LINES

Associated Companies

LEE WILSON ENGINEERING CO.
CLEVELAND, OHIO

FLINN & DREFFEIN CO.
CHICAGO, ILL.

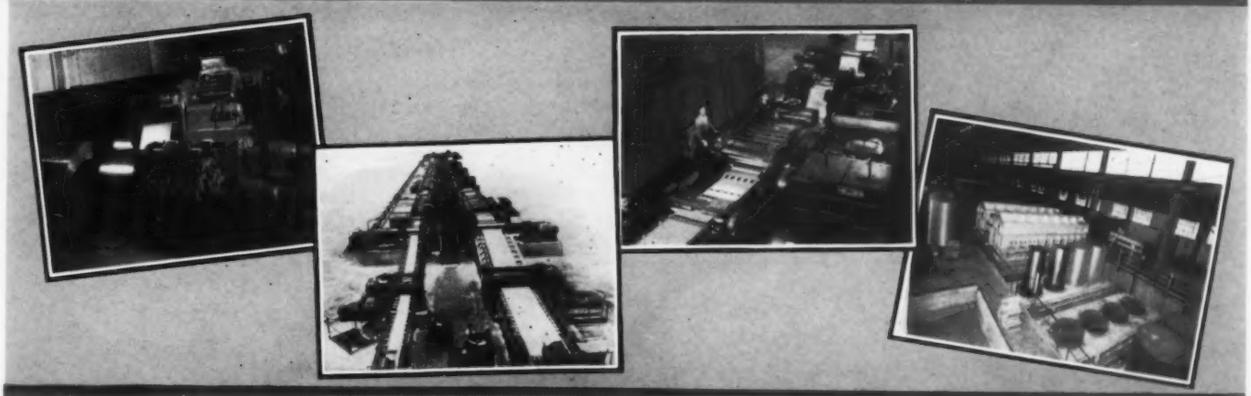
THE McKAY MACHINE CO.
YOUNGSTOWN, OHIO

THE HALLDEN MACHINE CO.
THOMASTON, CONN.

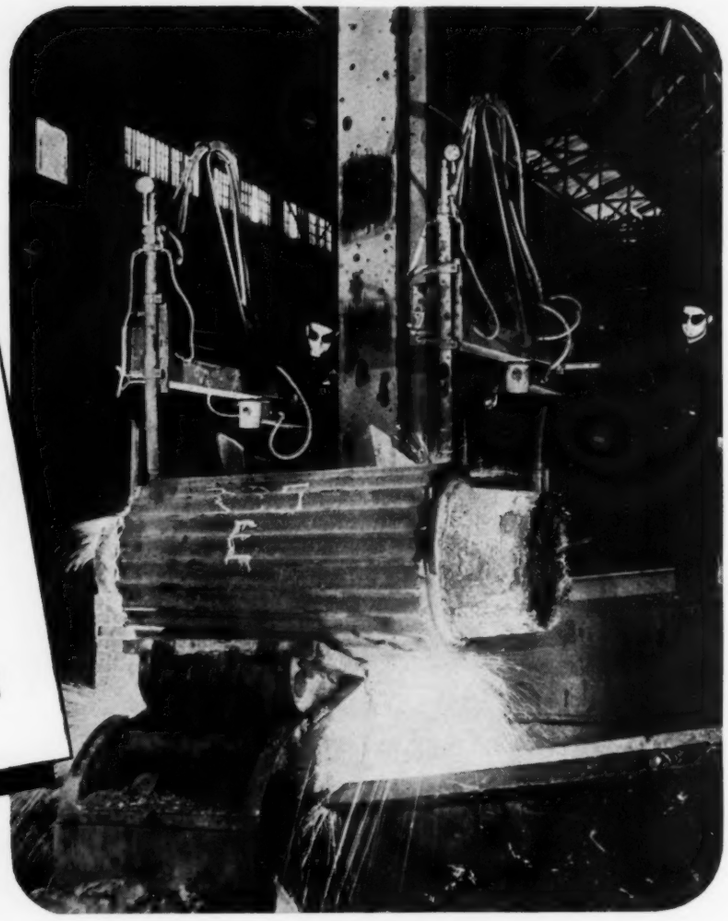
THE WELLMAN SMITH OWEN ENGR. CORP., LTD.
LONDON, ENGLAND

THE WEAN ENGINEERING CO. OF CANADA, LTD.
HAMILTON, ONT.

Subsidiary Company
THE BRODEN CONSTRUCTION CO.
CLEVELAND, OHIO



★ ★ SPECIAL MACHINERY *for* WAR PURPOSES ★ ★



36" Ingots CROPPED IN 8 to 10 Minutes WITH THIS SPECIAL AIRCO INGOT-CUTTING MACHINE

Big corrugated ingots — up to 36" thick — are now cropped at both ends simultaneously with this specially built Airco gas-cutting machine. On the average, these large ingots are completely cropped in approximately 10 minutes.

The machine used for this operation is a special development of Airco Engineering and Research. The two cutting torches are mounted on mechanized arms which automatically move the torches in an arc corresponding to the upper circumferential contour of each end of the ingot. One torch may be set for cutting ingot ends of 26" to 36" dia., while the other torch has a range of 16" to 26" dia. In this way tapered ingots may be cropped cleanly in a single, fast cutting operation.

The ingots are swung into position by a crane and rest on the dumping pedestal shown in the illustration. When the cut is completed, the cropped ends of the ingot drop into pits located directly in front of the machine. The pedestal is then tripped, allowing the ingot to roll off while another ingot is swung into position. As a special safety feature, the dumping pedestal cannot be tripped by one operator unless his partner releases his safety catch.

This "tailor-made" Airco machine is a typical product of Air Reduction research and engineering, working in cooperation with a customer, to help solve a specific production problem. The same service, backed by years of know-how in the use of the oxyacetylene flame and the electric arc, is available to all Airco customers.

★ BUY UNITED STATES WAR BONDS ★

AIRCO WILSON

AIR REDUCTION

General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

In Texas: MAGNOLIA AIRCO GAS PRODUCTS CO. • General Offices: HOUSTON, TEXAS

THE Nameplate ON THE CONTROL IS EC&M

For Main, Auxiliary and Boom Hoists, typical Wright Dynamic Lowering Controller, as shown at left, is used. For 2-motor Rotate-motion, Typical Duplex Controller, at right, is used.

Typical Quadruplex Bulletin 921 Controller as used on 8-motor Travel-motion. Each leg has 2 motors in series with all four sets of motors operated in parallel.

EC&M Bulletin 1182 Type NT Master Switch for all motions, shown at left. Each motor is equipped with a Bulletin 1004 Type WB Brake, series-wound for Hoist motors, shunt-wound for Rotate and Travel motors.

THIS is called a fitting-out and repair crane used for ship construction. Several of this type have been built and placed in service quickly. No designer of the first hoisting-machines could ever have dreamed of units of such size . . . such mobility . . . produced so rapidly.

The Allies have been fortunate in that crane builders have satisfied the need for so many war-goods-handling equipments in such a prompt, efficient manner.

Control, although a small part of the cost, is a vital part of every crane. It protects as well as speeds operation. Line-Arc Contactors and Time-Current Relays respond quickly. For 2 or 4 mechanically-connected motor-drives, EC&M Duplex and Quadruplex Controllers keep the motors in step electrically. "Knowing how" can be of great value in getting the most from your cranes, *safely*. Specify EC&M Control.

A free copy of Booklet 920, "How to Operate a Crane" will be sent on request.

THE ELECTRIC CONTROLLER & MFG. CO.

2700 East 79th Street ★ Cleveland 4, Ohio

SWINDELL HIGH TEMPERATURE CAR-TYPE FURNACES

LET US CONSULT ON YOUR PRESENT FURNACE PROBLEMS

SWINDELL-DRESSLER Corporation

DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES

PITTSBURGH, PA.

Ol' Red Wabbler says:

3 times the wear of ordinary rolls

in 4 great steel plants with Nironite C-B Work Rolls

In hot strip mills, Mackintosh-Hemphill Nironite C-B Work Rolls have proved to have three times the wear of ordinary rolls. This greater wearing quality means lower costs and increased tonnage from the same set of rolls.

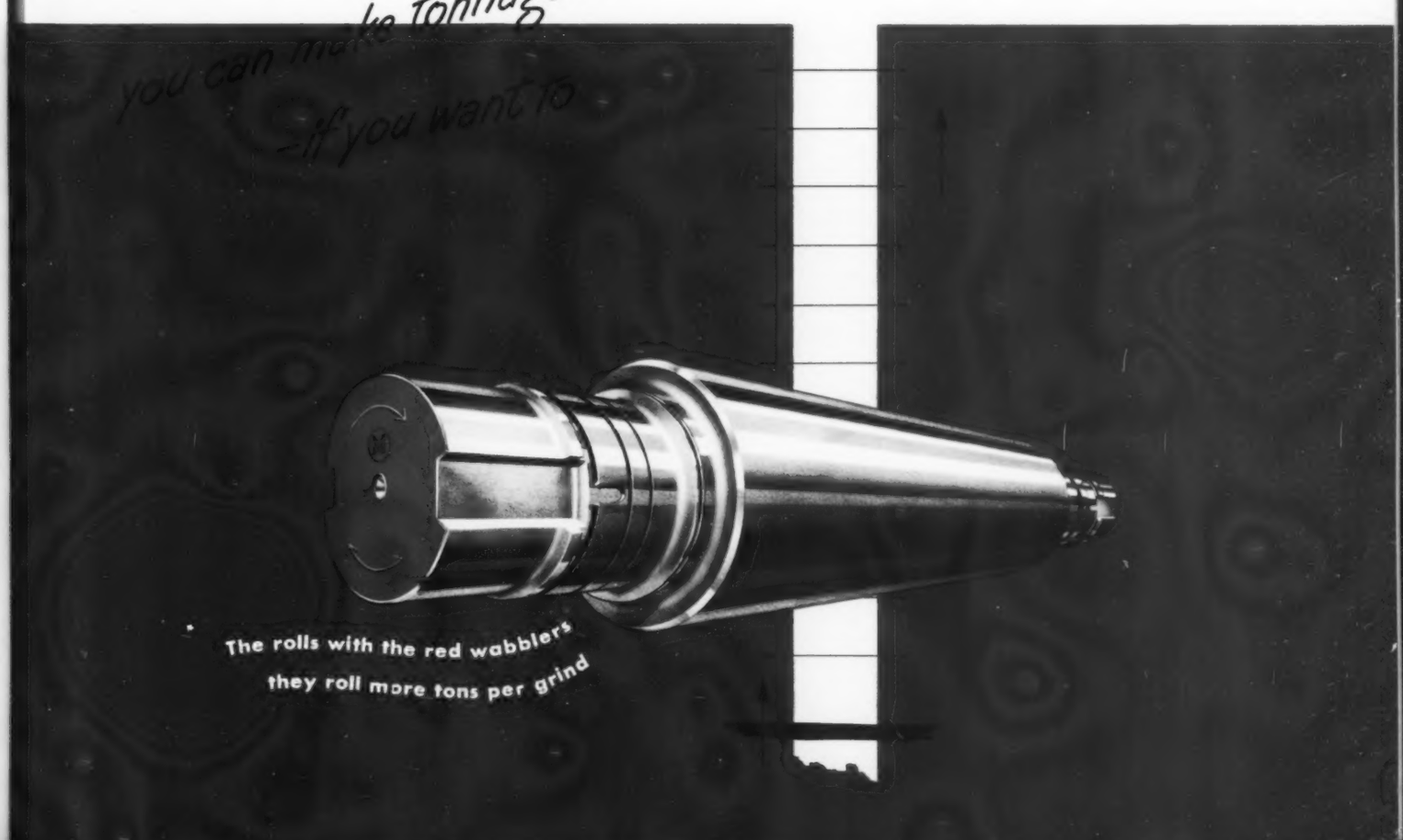
M-H Nironite Rolls are high nickel chromium alloy iron, of the grain or indefinite chill type. The body surface structure very closely approaches that of true chill and the body centers and necks are tough and strong. They are ideal for flat work. These rolls are rapidly supplanting the true nickel chill types for Strip Mill Intermediates. They will not spall; give better finish and greater tonnage per grind. Because of their surface likeness to chill and freedom from spalling, the Hard Grade "D" has in a number of cases succeeded Forged and Hardened Steel Rolls for Cold Work.

Other Mackintosh-Hemphill products:

Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers . . . Pinions . . . Special Equipment . . . Iron-Steel Castings . . . The NEW Abramsen Straightener . . . Improved Johnston Patented Corrugated Cinder Pots and Supports . . . Heavy Duty Engine Lathes.

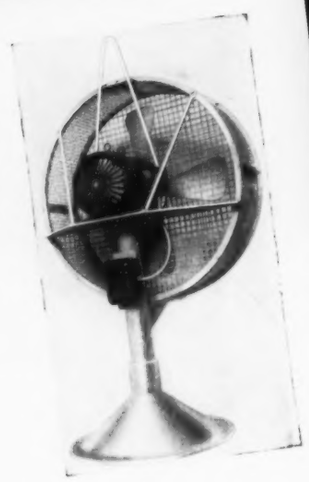
MACKINTOSH-HEMPHILL COMPANY, Pittsburgh and Midland, Penna.

you can make tonnage records if you want to

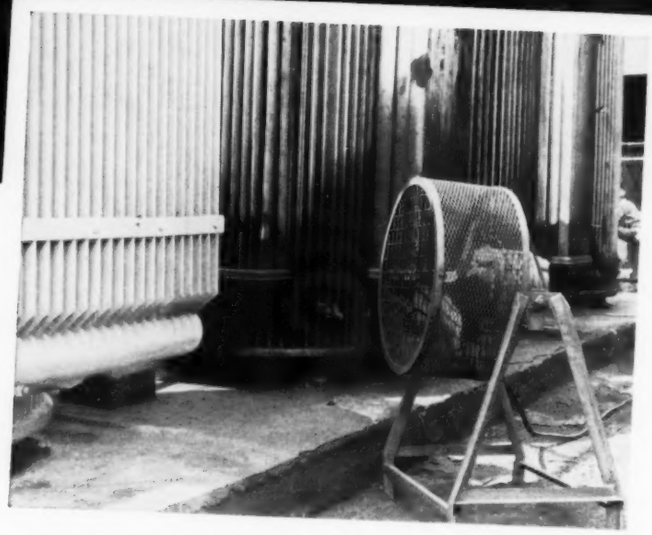


Let Truflo Fans . . .

Help keep your workmen on their toes

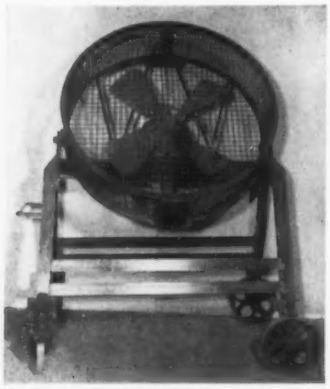


Portable Fan No. TF-100, recognized as standard in many of the country's largest mills. Sizes from 12 in. to 36 in. in diameter.



Portable Fan No. TF-300 in operation, cooling large transformers in strip mill.

Crane Cab Fan, for cooling crane cab interiors and other confined areas. Available in 12 in. and 18 in. sizes, adjustable both horizontally and vertically.



Portable Fan No. TF-300W. Angle iron support adjusts for vertical or horizontal discharge through almost 360°.

It's more important now than ever before to keep your workmen comfortable. For comfortable workmen are more efficient, produce more work in a given time.

Truflo Fans can help you keep your workmen on their toes. All Truflo Fans are designed and built correctly for efficient, economical operation — they move more air per dollar. Write for free literature on any of the following styles:

Portable Cooling Fans • Crane Cab Fans
Wall Fans • Exhaust Fans • Blowers
Roof Ventilating Fans • Pent House Fans

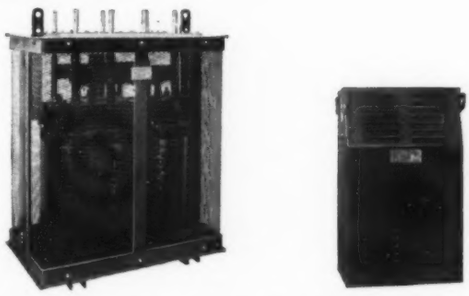
TRUFLO FAN COMPANY

554 MAIN STREET HARMONY, PA.

MOLONEY AIR-COOLED TRANSFORMERS

For Indoor Installation *Without* Fireproof Vaults

600 Kva, 3-Phase Type BDL Air-Cooled transformer with Class B insulation. Rated 13800 volts delta primary to 460Y/266 volts secondary with 6-2½% taps available on terminal board located on side of transformer.



Left: 150 Kva Type BDL transformer. Type BDL is supplied in sizes from 150 to 1500 Kva in primary voltages from 480 to 13800 volts. *Right:* Type BDC. This type is supplied in sizes 15 to 100 Kva in primary voltages from 480 to 4800 volts.

It's Safe and Economical to Install Type BDL and BDC Transformers Indoors

THESE Air-Cooled transformers are insulated with approved Class B materials including glass, asbestos and porcelain. Since no cooling liquid is used, fire and explosion hazards are eliminated and Type BDL and BDC transformers may be safely installed at load centers without the expense of vault construction.

Because of the absence of a cooling liquid, there is practically no maintenance cost when using either Type BDL or Type BDC Air-Cooled transformers. There is no liquid to require periodic testing and conditioning. There are no valves, no gasketed surfaces, no cooling tubes or radiators to maintain.

Type BDL transformers are contained in expanded metal cases and Type BDC in louvered sheet-metal cases. Both types of cases are attractive in appearance and make the most effective use of cooling air for the particular design of the windings involved. Large cooling ducts are provided in the windings to permit rapid movement of a large volume of cooling air. The windings are designed to provide a maximum amount of coil surface for efficient cooling.

Moloney Air-Cooled transformers with Class B insulation may be used safely and economically in all industrial applications.

MOLONEY ELECTRIC COMPANY • ST. LOUIS, U. S. A.

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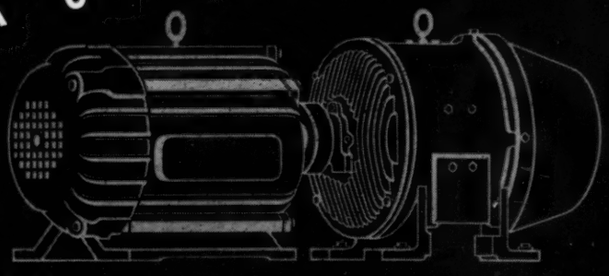
C-W

MARK OF DEPENDABILITY

SINCE 1888



C-W has been a *mark of dependability* on motors and generators for over 50 years.

Powering the war effort, on land and sea, may be found many Crocker Wheeler motors and generators which were made over a generation ago . . . yet are serving quietly, faithfully and economically, with a minimum of attention.

If you need rugged, dependable motors and generators, write or wire us, or consult our nearest office. We can make immediate shipment on many types.

CROCKER WHEELER ELECTRIC MANUFACTURING CO.
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For engineering and service information, call . . .

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Motors · Generators

Be SURE . . . with
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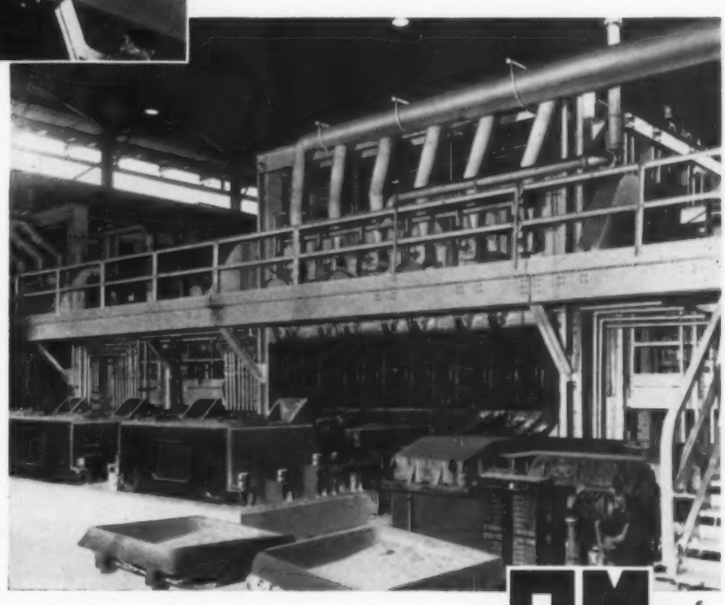
Other JOSHUA HENDY IRON WORKS factories at Sunnyvale, Pomona, Torrance, and Long Beach, California, and St. Louis, Mo.

AMCO

Continuous Recuperative

SLAB AND BILLET HEATING FURNACES

AMCO Continuous Slab Heating Furnaces and AMCO Pit Furnaces were selected to serve a large, new American Plate Mill

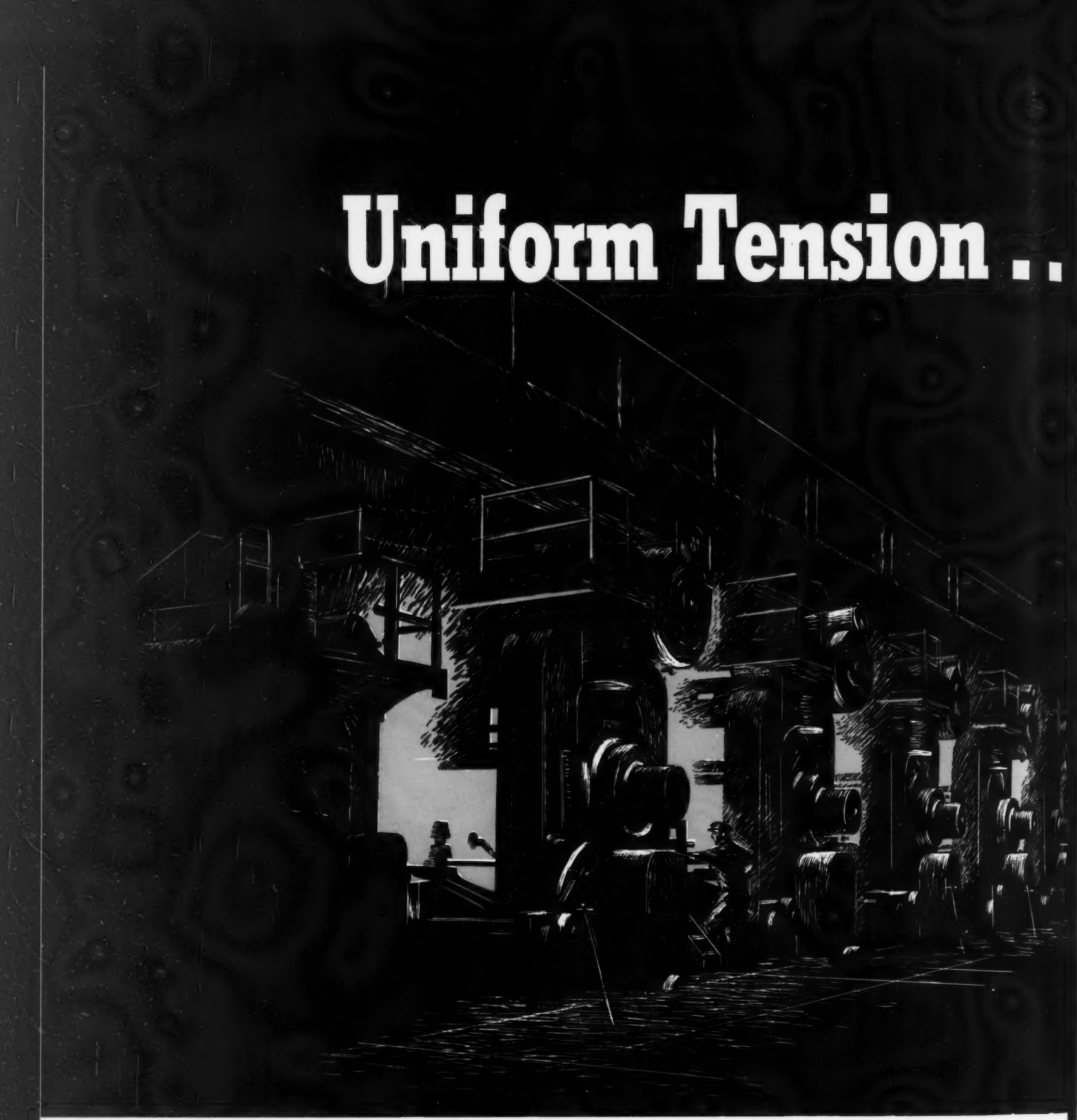


Amco Also Builds Open Hearth, Recuperative Side-Door Heating, and Heavy-Duty Forge Furnaces

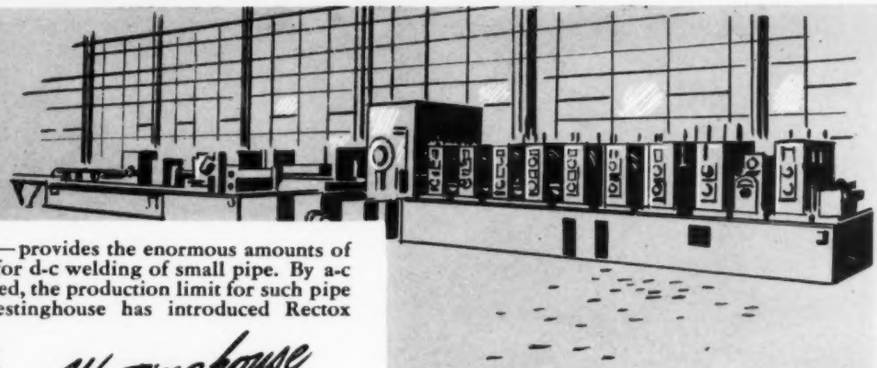
The **AMSLER-MORTON** *Company*

FULTON BUILDING • PITTSBURGH, PA.

Uniform Tension . . . .



NEWS OF WESTINGHOUSE SERVICES AND PRODUCTS FOR THE STEEL INDUSTRY



PIPE WELDING . . . Rectox—provides the enormous amounts of low-voltage current necessary for d-c welding of small pipe. By a-c welding methods previously used, the production limit for such pipe was 70 feet per minute. Westinghouse has introduced Rectox power conversion for d-c welding. This has made it possible to increase the production rate to 360 feet per minute, also eliminating the stitch effect.

Westinghouse

...FOR CONTINUOUS

STRIP MILL OPERATION

Few developments in industry have been so spectacular and rapid as the continuous cold rolling of sheet and tin plate. Within the short span of a dozen years, delivery speeds have been increased sevenfold. Today, the nation's mills are turning out strip by the continuous process at 2500 feet per minute, to fill the needs of a nation at war.

Continuous cold rolling of strip has imposed two conditions of successful operation; the maintenance of unbroken strip, and the maintenance of uniform gauge. Since it has become the practice to roll with tension, as a partial control of gauge, both of these conditions of successful operation are a function of the tension maintained in the strip.

Just as Westinghouse pioneered the introduction of the first tandem cold reduction mill and the first reversing cold reduction mill drive, so the solution to this problem of tension has been provided by another Westinghouse-developed steel-mill device, the Tensiometer.

By means of the Tensiometer, tension between the stands is measured accurately, instantaneously, and without interrupting the process, thereby permitting adjustment of the drive motors to maintain uniformity of gauge and continuous, unbroken strip. In this way, electrical engineers once again have advanced to meet the increasingly exacting demands of steel mill technology.

This ability to provide simple electrical solutions to complex mechanical problems is a service that can play an equally important part in the successful operation of your steel mill equipment. For competent engineering help in meeting your production requirements, just call your nearest Westinghouse representative. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania. J-94590

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

WESTINGHOUSE ENGINEERING SERVICE

A nationwide corps of engineers offers you electrical and production experience gained through years of working with the steel industry.

In addition to engineering help on specific industry problems involving electrical power, these men can give you assistance on these other vitally important activities:

PRODUCT DEVELOPMENT: engineering of equipment to meet war requirements.

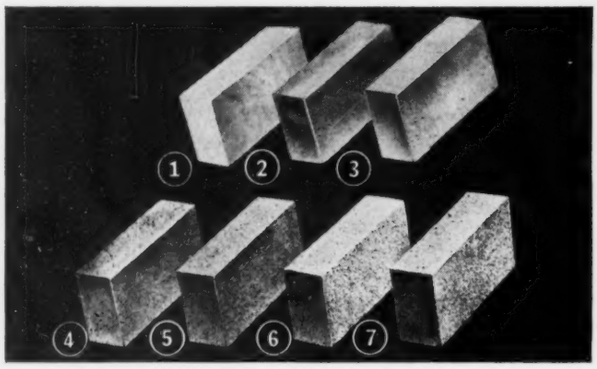
MAINTENANCE: help in making existing equipment serve better, last longer.

REHABILITATION: redesigning and rebuilding obsolete equipment for useful service.

MATERIAL SUBSTITUTION: adapting available replacements for critical materials.

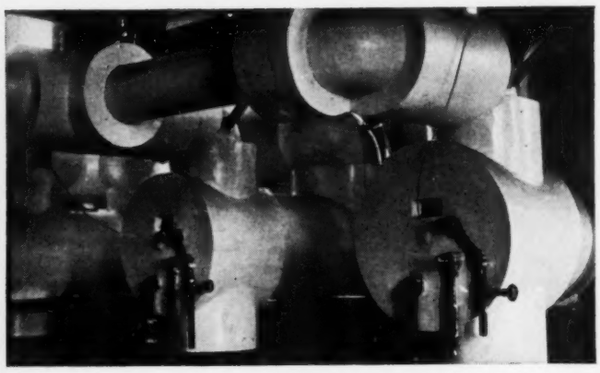
W.E.S. is available to all branches of the steel industry. Put it to use today on your production problems.

Solutions TO YOUR TOUGH INSULATING PROBLEMS



SEVEN TYPES OF BRICK . . . Three types of insulating brick: (1) Sil-O-Cel Natural Brick for temperatures to 1600 F; (2) Sil-O-Cel C-22 Brick for temperatures to 2000 F; (3) Sil-O-Cel Super Insulating Brick for temperatures to 2500 F. Four types of insulating fire brick—(4) JM-16 for temperatures to 1600 F (or to 2000 F behind refractory protection); (5) JM-20 for temperatures to 2000 F; (6) JM-23 for temperatures to 2300 F; (7) JM-26 for temperatures to 2600 F.

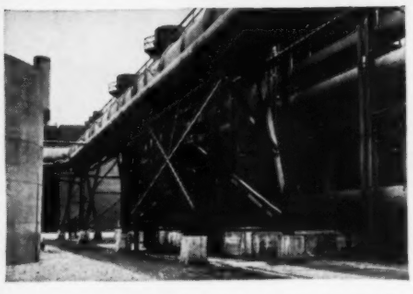
All provide light weight, low cost, low conductivity. Furnished accurately sized in all standard sizes of the 2½" and 3" series, as well as in specials.



POWER PLANT INSULATIONS . . . For many years the most widely used power plant insulations, Johns-Manville 85% Magnesia Blocks and Pipe Covering are today lighter in weight and more efficient than ever before. Standard-size blocks are 3"x18", 6"x36" and 12"x36"; from 1" to 4" thick. Other sizes, including lagging, furnished on special order. Pipe insulation is available in 3-foot lengths in thicknesses up to 3". For temperatures above 600 F, Superex Combination Block or Pipe Insulation is recommended—an inner layer of high-temperature Superex and an outer layer of 85% Magnesia. Sizes same as those of 85% Magnesia.

LASTINGLY EFFICIENT BLOCK INSULATION . . . J-M Superex meets every steel-mill need for temperatures to 1900 F. Combines high heat resistance and great durability with unusual insulating value. Standard sizes 3"x18", 6"x36" and 12"x36"; from 1" to 4" thick. Other sizes and thicknesses on order. J-M 85% Magnesia or Asbesto Sponge Felted are often used outside of Superex. This construction is known as J-M Superex Combination Insulation.

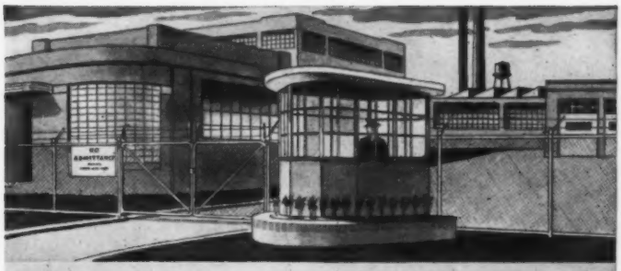
SEMI-REFRACTORY INSULATING CONCRETE ... Sil-O-Cel C-3 Concrete is the ideal material for lining furnace doors and for insulating furnace bases. Cast on the job, it sets up into a strong, durable, insulating concrete for temperatures to 1800 F. Furnished in 100-lb. bags.



PIPE INSULATION FOR STEAM LINES UP TO 700 F ... J-M Asbesto-Sponge Felted Pipe Insulation is recommended where maximum efficiency, high salvage and resistance to abuse are essential. For temperatures over 700 F, used in combination with Superex. It is available in 3-ft. sections, from 1" to 3" thick, for standard pipe sizes. Integral waterproof jacket for outdoor use.

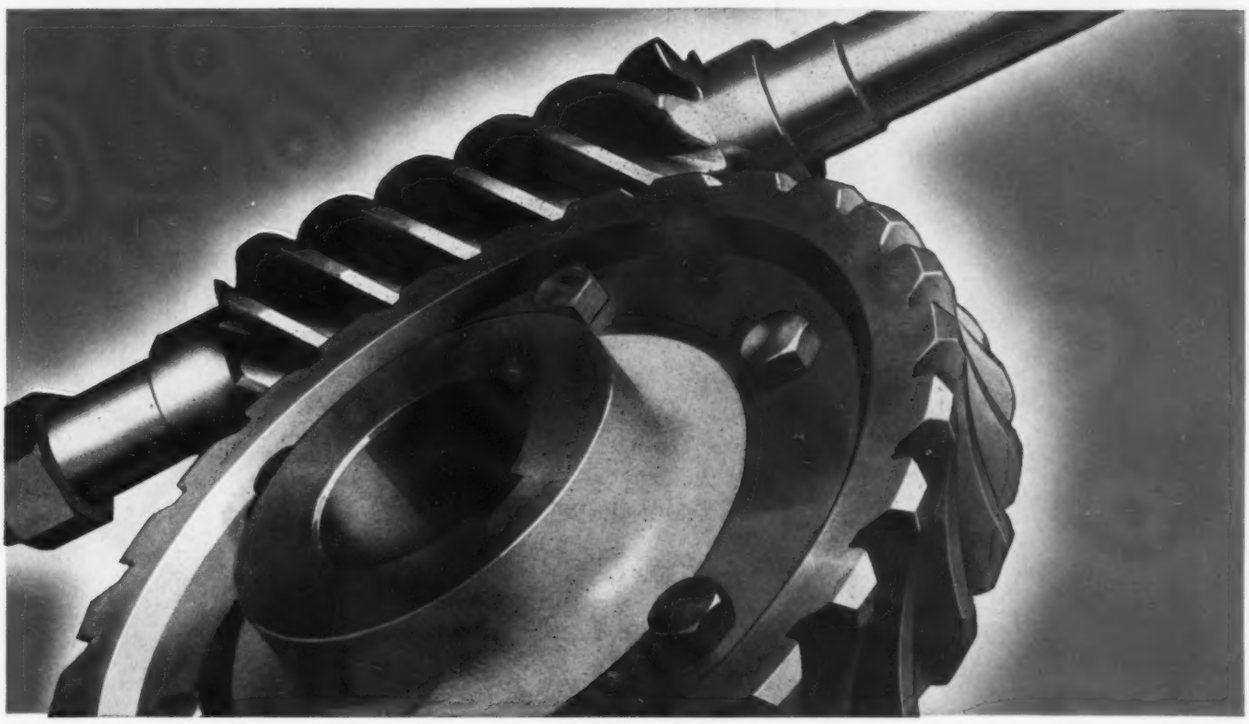
THESE ARE BUT A FEW of the many Johns-Manville Insulations that are helping assure dependable, uninterrupted operation of all types of heated equipment in the iron and steel industry. One may solve *your* insulating problem. For details on all J-M Insulations, write for Catalog GI-6A. Johns-Manville, 22 East 40th Street, New York 16, N. Y.

JM Johns-Manville **INDUSTRIAL INSULATIONS**



All day today and

all night tonight



Straight through every minute of the 24 hours your Cleveland Worm Gear Speed Reducers stand competent guard—they deliver dependable power to keep equipment going, come what may.

That's what they're built to do of course—yet Clevelands' almost endless capacity to absorb punishment and keep driving ahead is one of the things that the oldest customers mention most often with greatest appreciation. To quote from just a few:—

"Our Cleveland Units have run 24 hours a day for 8 years . . . we have never opened the housings"—*steel products industry.*

"Twenty-four hours a day beginning 1929—our Clevelands get no special attention"—*heavy metals.*

"For nearly 20 years Clevelands have given uniform operation, minimized shutdowns"—*copper and brass.*

"Day and night since 1923; Clevelands insure uniform operation"—*portland cement.*

"Around the clock for 20 years—Clevelands keep our equipment going"—*mechanical rubber.*

"Our equipment *must* run continuously—Clevelands have prevented shutdowns here for more than 10 years"—*glass industry.*

Designed and built for peace, Clevelands today are doing a big wartime job. Count on them to stand by you always—all day today, all night tonight.

The Cleveland Worm & Gear Company, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication
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CLEVELAND WORM GEAR

SPEED REDUCERS

This cable resists:

HEAT

ACIDS

OILS

MOISTURE

Okolite-Okoprene cables successfully meet the hazards of industrial plant operation. Insulated with Okolite and protected by an Okoprene* sheath, they are heat resistant and can be used in circuits running near blooming mills, furnaces, soaking pits, boiler rooms, steam lines and pouring ladles. Resistant to the solvent action of grease and oils, Okoprene is not deteriorated by the cutting oils used on pipe-threading machines or by lubricating oils from cold-rolling mills. Acid problems existing near pickling and plating tanks are overcome by Okoprene. Over and above this the toughness, flexibility and abrasion resistance of the Okoprene covering mean unexcelled ability to withstand mechanical abuse.

Okolite-Okoprene cables are made in a full range of capacities, and sizes for all electrical applications. Write for Bulletin OK-2009B. The Okonite Company, Passaic, N. J.

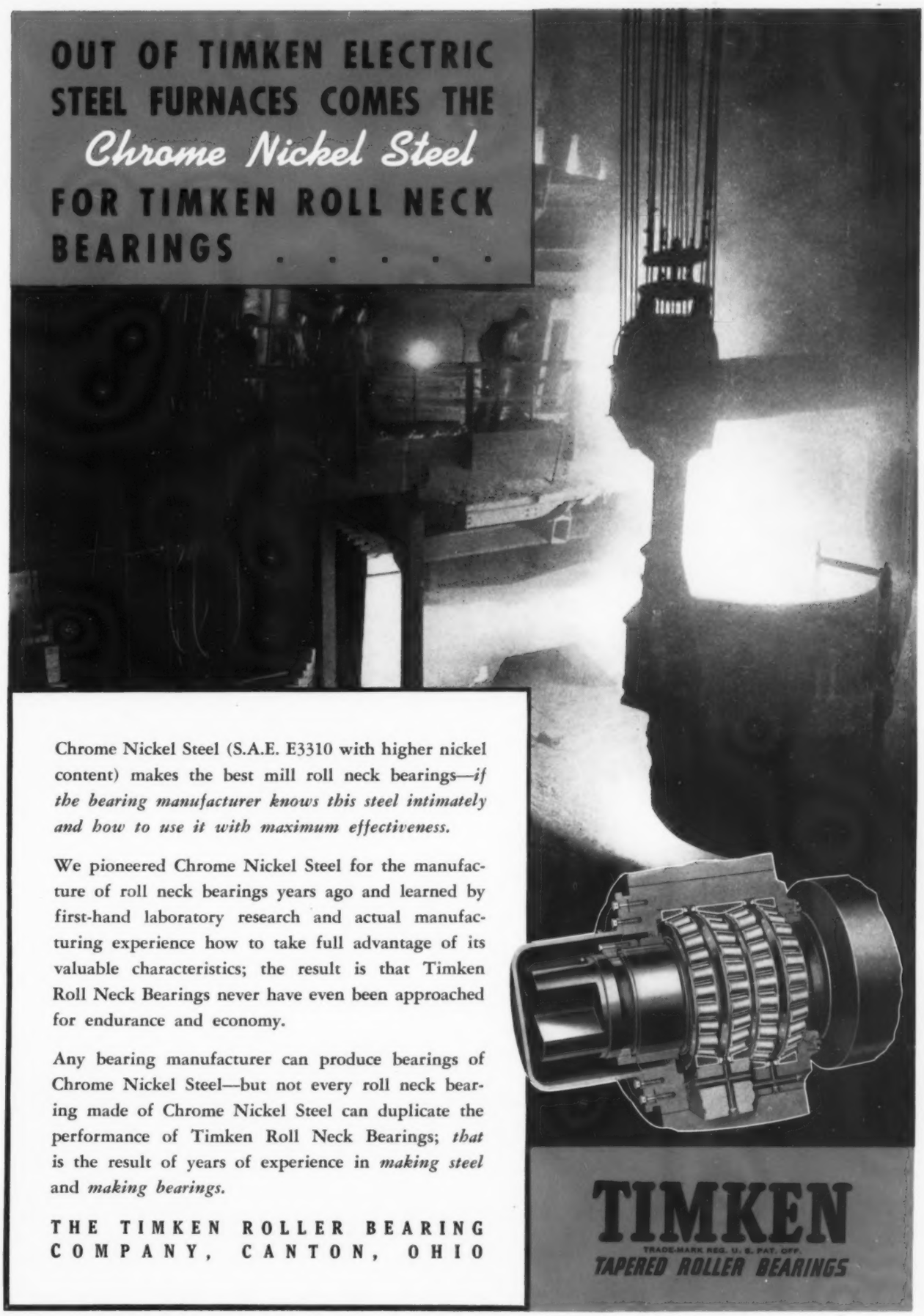
*A neoprene protective covering developed by Okonite for severe applications. Resistant to moisture, flame, oil and sunlight, Okolite-Okoprene cables can be installed in ducts, buried directly in the earth, or exposed to the elements — *without additional protection.*

3396

Okolite-Okoprene

THE OKONITE COMPANY
INSULATED WIRES AND CABLES

OUT OF TIMKEN ELECTRIC STEEL FURNACES COMES THE *Chrome Nickel Steel* FOR TIMKEN ROLL NECK BEARINGS . . . . .



Chrome Nickel Steel (S.A.E. E3310 with higher nickel content) makes the best mill roll neck bearings—*if the bearing manufacturer knows this steel intimately and how to use it with maximum effectiveness.*

We pioneered Chrome Nickel Steel for the manufacture of roll neck bearings years ago and learned by first-hand laboratory research and actual manufacturing experience how to take full advantage of its valuable characteristics; the result is that Timken Roll Neck Bearings never have even been approached for endurance and economy.

Any bearing manufacturer can produce bearings of Chrome Nickel Steel—but not every roll neck bearing made of Chrome Nickel Steel can duplicate the performance of Timken Roll Neck Bearings; *that* is the result of years of experience in *making steel* and *making bearings.*

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

HIGH PRODUCTION HEAT TREATING

WITH LOW B.T.U. FUEL

Over 30 tons of alloy steel per hour at 2250° F. is the production rate of this installation of five Salem double chamber, batch type furnaces. *It is operated by only two men,* from charging through pre-heating and soaking to unloading. High carbon, low carbon, and alloy steels—ingots, billets, and slabs—all are heated equally well. Using oil as a fuel, precise controls permit variation of atmosphere and temperature to suit the product being heated.

Similar Salem installations, operating with low B. T. U. gases, show equally good results when equipped with Salem Needle Metallic Recuperators, which pre-heat either gas or air for greater combustion efficiency and higher furnace temperatures. It will pay you to investigate how Salem furnaces can increase your production while saving 25% to 30% on your fuel bill.

Above are banks of Salem Needle Type Recuperators. By producing the most favorable degree of turbulence in air and waste gas streams, Salem's exclusive needle design provides maximum transfer of heat from waste gases to air with a minimum of back pressure. Made of Liesconit, these preheaters may be standard equipment on Salem billet heating furnaces, or they may also be installed in conjunction with your present furnace for higher efficiency.

SALEM ENGINEERING COMPANY

SALEM ENGINEERING CO. · SALEM, OHIO

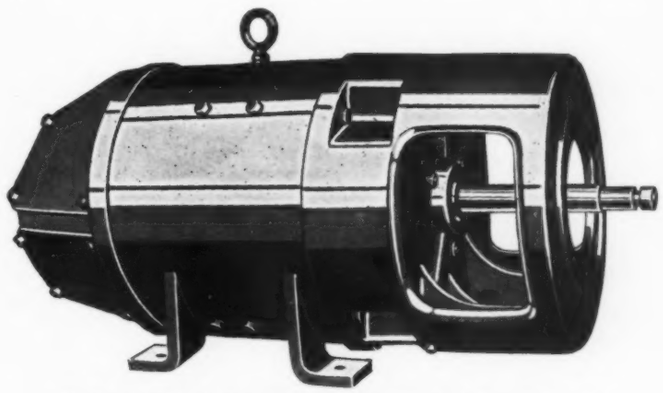
In the early days, this was the peak of streamlining.

STREAMLINING!

Streamlining adds more than beauty. For years, Reliance engineers have pioneered in streamlining electric motor-drives—*for utility and efficiency.*

Among recent developments are axial-flow fan motors, close-coupled pump motors, V★S Adjustable-speed Drive. These and other Reliance Motors are being used in many highly efficient steel mill installations where space is limited . . . where flexibility of power control and ease of operation are essential . . . where safety is a prime factor . . . and trim appearance desirable.

For further advantages of streamlined motor-drive and practical design suggestions, call in a Reliance man.



Reliance Splash-Proof D-c. Close-coupled Pump Motor. Pump is mounted right on the motor shaft—eliminates misalignment, saves space; fewer parts, less maintenance.

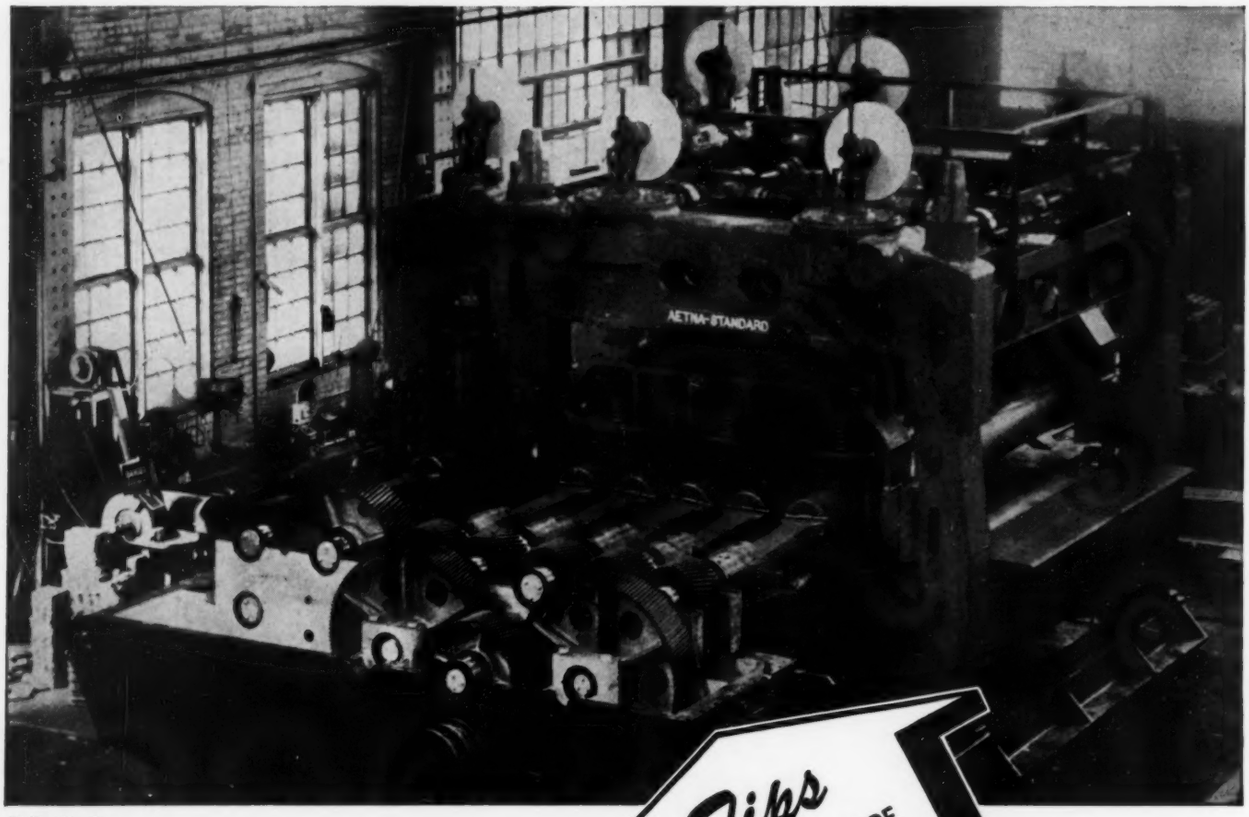
RELIANCE A·C D·C MOTORS

RELIANCE ELECTRIC & ENGINEERING CO.

1088 Ivanhoe Road • Cleveland, Ohio

Birmingham • Boston • Buffalo • Chicago • Cincinnati • Detroit • Greenville (S.C.) • Houston • Los Angeles • Minneapolis
New York • Philadelphia • Pittsburgh • Portland (Ore.) • St. Louis • San Francisco • Syracuse • other principal cities.

CAREFREE *running assured*
BY SKF ROLLER BEARINGS

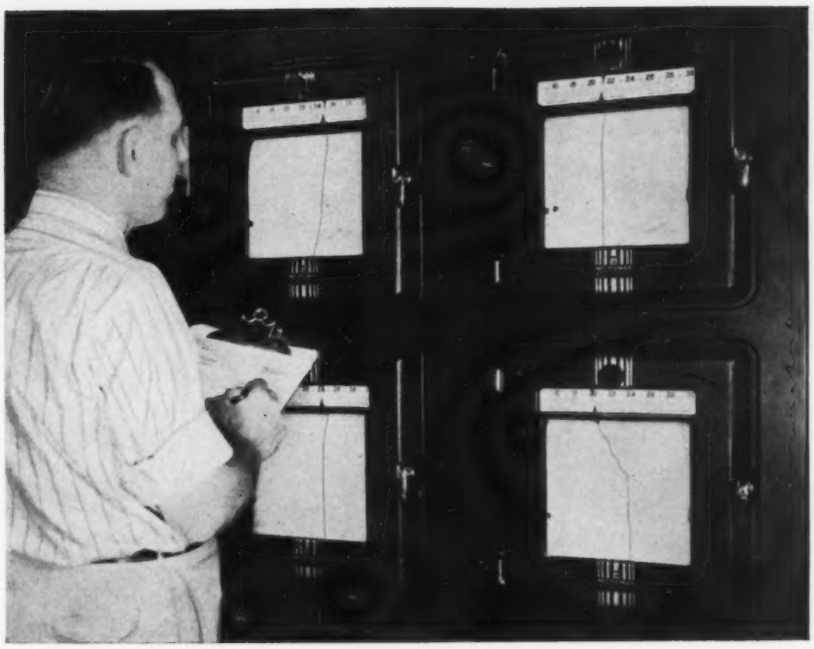


● *Built by*
THE AETNA-STANDARD ENG'G CO.

LOOK FOR SKF Bearings on the 375 h.p. drive of this machine which levels 132" alloy steel plates 5/8" to 1¼" thick at 300 feet per minute. Look for them where high load carrying capacity is always available for useful work—where breakdowns and the high cost of tearing-down for bearing replacements are at a minimum. That's where the predominant features are continuous peak production under severe conditions, consistent accuracy and long bearing life . . . where Performance is a *must* in the manufacture of war materials. 5397

SKF INDUSTRIES, INC., PHILA., PA.

Tips
ON BEARING CARE
To make present equipment last longer
1. Use clean lubricant recommended by the manufacturer of this machine.
2. Avoid loads and speeds beyond those recommended by the manufacturer.
3. If necessary to remove bearings, keep them properly lubricated. Avoid the intrusion of water and dirt. Apply pressure on the inner race only. Don't hammer outer race.
SKF
BALL AND ROLLER
BEARINGS



Close control of furnace temperature, being maintained by Micromax Pyrometers in plant of Houze Glass Co., Pt. Marion, Pa. Record curves have been strengthened to make them visible, but not otherwise altered

MEN ON THE "FURNACE" FRONT

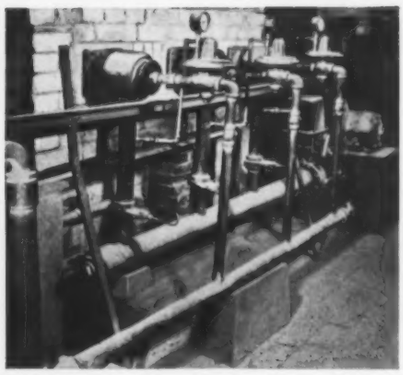
Are Winning With Micromax Control

The enemies of uniform temperature in the Houze Glass Company's war-busy furnaces include changes in furnace load; fluctuations in fuel pressure; leaks and infiltration; changes in wind, weather, season, human skill and attentiveness, and all other factors which interfere with a furnace's output.

Houze, however, allows no such enemy or combination of enemies to interfere in the operation of furnaces and have adopted automatic furnace control to help assure maximum production.

The furnaces under regulation are one-ton pot-type units. They are fired with gas, through a burner and manifold in which the volume of gas is held proportional to that of combustion air; air is the fuel element which is actually throttled to regulate temperature.

After considering various throttling plans, Houze engineers decided on the balance type of control, which balances each change in the temperature of the furnace by making a proportional change in air-and-gas. And, in order to get maximum sensitivity with dependability in this Control, Houze engineers selected Micromax Pyrometers to direct the throttling and to record the temperatures.



Gas and air reach the Houze furnaces through proportional-mixing type burners, arranged in threes. Air-flow is regulated by a Micromax Electric Control valve-drive; gas-flow is held proportional because air-pressure from the header regulates the diaphragm valve in the gas line. A simple set-up which nevertheless enables the Micromax to regulate temperature with utmost dependability

Results have more than justified their choice. Even when temperature changes are too small visibly to affect the Micromax, it "feels" them and edges the butterfly air-valve up and down — down and up again — holding temperature balance in the narrow band of high-quality, high-production war work.

For further information about this or any other wartime-temperature control problem, ask for engineering service, or for the appropriate catalog.

Fyrestan Tube complete with Ferrule, fitted to L&N PI-181 Couple Head.

QUICK DELIVERY OF TUBES FOR THERMOCOUPLES

To help save metal in the present emergency, we can now supply tubes made of "Fyrestan" ceramic ware, to replace, whenever desirable, the iron, steel and alloy tubes which protect base-metal thermocouples. Fyrestan has long been our standard for temperatures too high for alloys, and we hope that its availability in the alloy range will now give many firms an opportunity to reduce the number of metal tubes they require.

An additional reason for adopting Fyrestan wherever possible is that it can usually be shipped much more promptly than metal tubes.

Fyrestan is of course not as strong as metal, but it is fully as gas-tight. Its life in service is comparable with that of metal, and in some instances, in the range 1800 to 2000 F, it should outlast an alloy. In general, it can be used for all applications except the following:

1. Immersion in molten metals and certain molten salt baths.
2. Where unsupported length exceeds 36 in. vertically or 18 in. horizontally.
3. Where work in furnace may strike tube.
4. Where tube is withdrawn frequently.
5. Where furnace pressure is more than 1 lb per sq in.

When you need tubes, ask about Fyrestan.

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Jrl Ad EN-0720(18b)

THE *Strategy* OF MAN-POWER

RELIEVING VITAL MAN-POWER of unnecessary fatigue . . . avoiding unnecessary handling . . . saving unnecessary steps . . . keeping a constant flow of material moving to waiting hands and machines, that's man-power strategy headed towards victory.

America's war industries from coast to coast are improving their per-man-and-machine-hour production schedules with the aid of Mathews Time-Coordinated Conveyer Systems.

If you are manufacturing war material, or anything vital to the success of the war effort, you can get Mathews Conveyers to handle that material. Rely as usual on your Mathews Engineer.

MATHEWS CONVEYERS FOR MECHANIZED PRODUCTION

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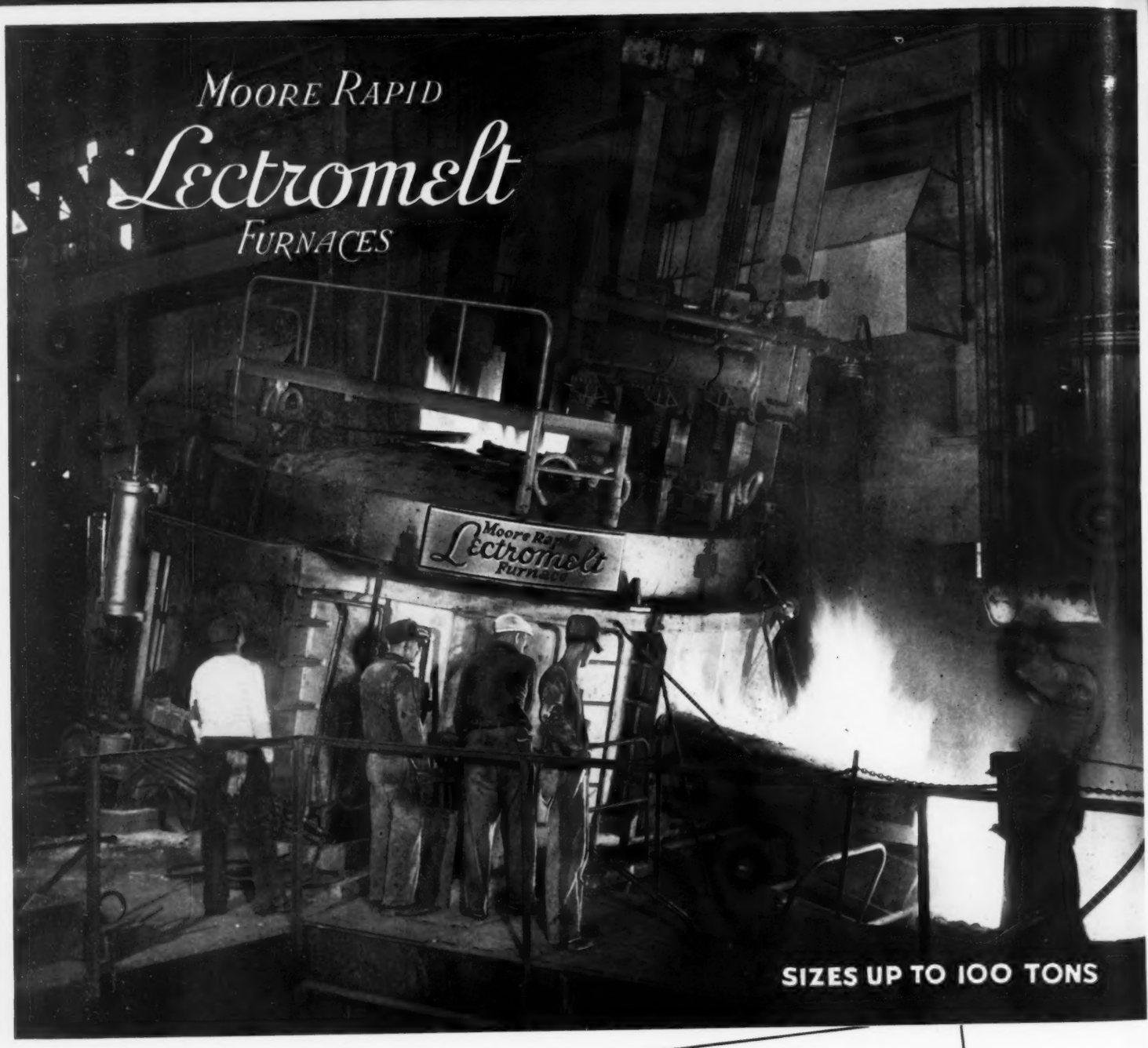

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PITTSBURGH LECTROMELT FURNACE CORPORATION

PITTSBURGH, PENNSYLVANIA

New 140 INCH Plate Mill AT Alabama Plant

. . . . through ingenuity and cooperation, the engineers of T. C. I. rebuilt and enlarged a plate mill with a loss of only 30 hours of possible rolling time . . . .

by J. D. Clark, CHIEF DRAFTSMAN

TENNESSEE COAL, IRON AND RAILROAD COMPANY

ENSLEY, ALABAMA

▲ THE installation of a wide plate mill now operating at the Fairfield Steel Works of the Tennessee Coal, Iron and Railroad Company has particular significance at this time, in view of the increasing demand of steel plates and especially for wider plates for ships and other implements of war sorely needed by our country. It is also worthy of comment that plates formerly manufactured at Fairfield Works were produced on a plate mill constructed during the first World War.

It is necessary that a brief outline be made, first, on the old plate mill, as it was remodeled to obtain increased production and wider plates by the changing of a 110 in. plate mill layout into a 140 in. plate mill.

110 IN. PLATE MILL BEFORE REMODELING

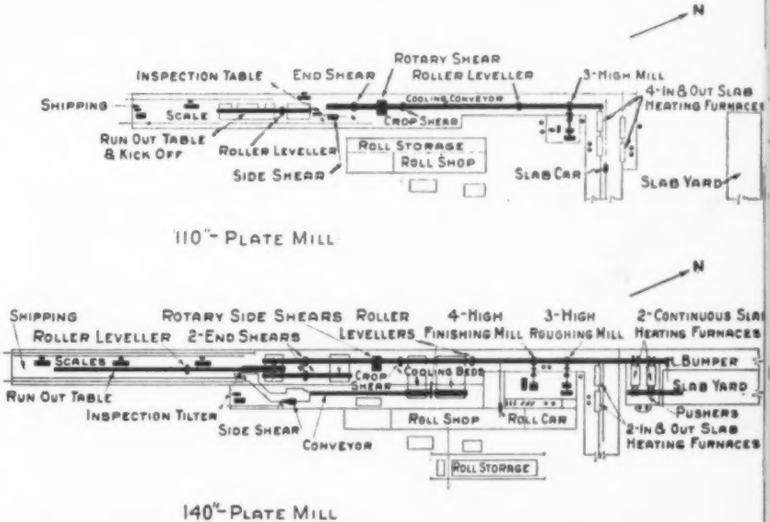
The 110 in. plate mill, shown at the top of Figure 1, was installed in 1918 to produce finished steel plates up to 98 in. wide, 60 ft long and $\frac{3}{16}$ in. to $1\frac{1}{8}$ in. in thickness.

The major units in this mill consisted of four slab furnaces; one 36 in. x 110 in. three-high plate mill; two roller levelers; cooling conveyor; crop shear; a rotary side trimming shear; end and side shears; tables; conveyors; finishing and shipping facilities.

The plates were produced from rolled steel slabs obtained from either of two blooming mills located nearby. These slabs were transferred to the furnaces by slab cars, routed either directly from the blooming mills or the slab storage yard. The slabs were charged and removed from the furnaces with overhead tong type charging cranes which placed the heated slabs on a motor driven slab car for delivery to a 36 in. x 110 in. three-high plate mill. This mill rolled the slabs into finished plates. Nine to twenty-three passes were required, depending on the slab size and the finished product.

After rolling, the plates were hot leveled on a nine-

Figure 1 — General arrangement of plate mill before (top) and after rebuilding and enlarging.



Presented before A. I. S. E. Birmingham District Section Meeting, March 29, 1943.

Figure 2 — An existing slab yard runway was relocated and extended to serve the plate mill.

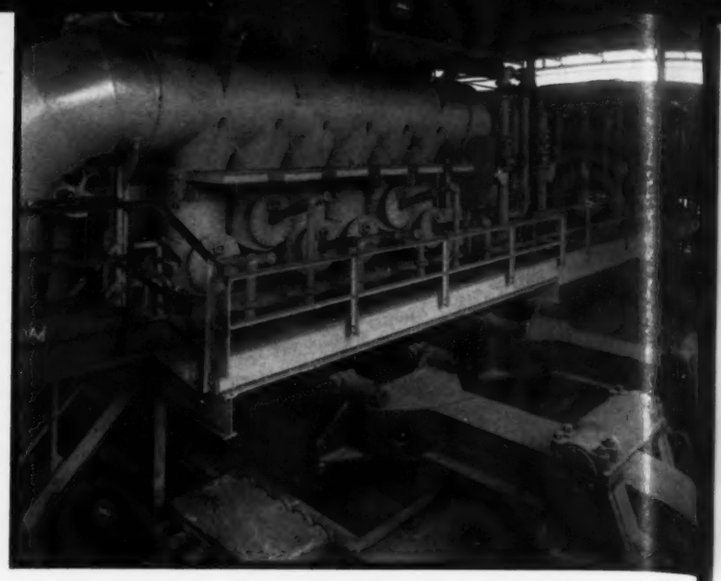


Figure 3 — Two new continuous heating furnaces have the novel feature of being fired principally from the charging end.

roll two-high motor driven leveler, from which they were transported over a chain conveyor for cooling before shearing. A motor-driven down-cut shear at the end of the cooling conveyor crop-sheared the front end of the plates. After this shearing operation, the plates were side trimmed to proper width by a motor-driven rotary shear unit. After side trimming, the plates were sheared to exact length as required by a second motor-driven down-cut shear.

After the shearing operation the plates were transported over a castor roller bed to a motor-driven inspection tilter. After inspection, the plates were conveyed into the shipping runway over roller tables arranged with kick-off arms on each side. These arms lifted the plates from the tables and deposited them on skids, in assorted piles, according to orders.

After the plates were piled on the skids they were carried by overhead cranes equipped with magnets or slings to platform weighing scales, from which they were loaded into railroad cars for shipment. A small roller leveler for leveling damaged plates and a circle shear were located in the shipping runway.

A 190 in. motor-driven down-cut side shear was provided for splitting wide plates, for side shearing plates from 1 in. to 1⅛ in. in thickness, and for special orders of miscellaneous sizes.

All plates over 1⅛ in. in thickness were flame cut to size with oxygen-acetylene torches.

Figure 4 — Auxiliary burners are mounted on the discharge end of the furnace, and serve to hold up steel temperature during mill delays.

140 IN. PLATE MILL AFTER REMODELING

The bottom of Figure 1 shows the plate mill after remodeling. This mill produces finished steel plates up to 128 in. wide, 60 ft long, 3/16 in. to 1¼ in. in thickness. The capacity of this mill is approximately 50 per cent greater than the old 110 in. plate mill.

The site for the new mill was occupied by the existing 110 in. plate mill. This location was selected in order to utilize part of the existing equipment and building structures where practicable.

Construction of this mill started in early spring of 1941. It was completed in early summer of 1942. The major existing units utilized from the 110 in. mill for the 140 in. mill were two in-and-out slab furnaces, the three-high mill, crop shear, rotary side trimming shear, one end and side shear, tables, one roller leveler and the overhead cranes. The major additional units provided were: two continuous slab heating furnaces with pushers and tables, one 140 in. four-high reversing plate mill, tables, two roller levelers, two cooling beds, three plate transfers, one end shear, plate inspection tilter, conveyors, additional roll shop equipment, overhead and gantry cranes.

The slabs for the plates produced on the 140 in. mill are obtained from either of the two blooming mills. They range in thickness from 4 in. to 15 in., up to 54 in. wide and up to 105 in. long, of a maximum weight of 18,000 lb. They are transferred from the blooming mills by slab cars to the slab yard runway. Figure 2 shows this runway with the various piles of slabs. These slabs are handled in the runway by overhead cranes

with magnets. An existing slab runway was relocated and extended.

The slabs are placed by the cranes on a roller table extending into the runway. This table transports them to the charging ends of two continuous slab heating furnaces shown by Figure 3. The slabs are charged into each furnace in two rows by motor-driven rack type pushers, two being provided for each furnace.

The furnaces are of continuous recuperative type, each having a hearth area of 20 ft x 60 ft. The rated heating capacity of each furnace is 50 net tons per hour of 8 in. thick slabs 105 in. long, charged in two rows. These furnaces employ a method of heating that differs from the conventional practice in that the principal firing is applied at the charging end and the waste gases blanket the steel on the soaking hearth. Top and bottom burners are employed for heating the slabs, supplemented with side burners on the soaking hearth. Mill delay burners are provided at the discharge end. The hearth in the heating zone is provided with four rows of insulated water cooled pipe skids. The soaking hearth is constructed of plastic chrome material without skids. Water cooled pipes are used for the discharge skids.

Three recuperator compartments are used for preheating the combustion air, two being used for the top waste gases, and one for the bottom waste gases. The waste gases travel in a downward direction through the recuperators to the stack flues. Combustion air at atmospheric temperature is delivered to the recuperators by motor-driven fans. The air travels in a criss-cross direction through the recuperators and is delivered to the burners at a temperature of approximately 1400 F. Manually operated dampers are placed in the stack flues from each recuperator.

Complete automatic temperature, fuel-air ratio and furnace pressure controls are provided. Coke oven gas is used as fuel. Figure 4 shows the discharge end of the furnaces. Heated slabs are conveyed over roller tables to the 110 in three-high mill which is used as a roughing stand.

Figure 5 — The original three-high 110 in. mill, driven by a 4000 hp motor, is now used as a roughing stand.

Two of the existing in-and-out furnaces are maintained for periodic operation for special orders and small weight slabs. These furnaces are in-and-out regenerative type, and have a hearth area of 11 ft 0 in. x 42 ft 6 in. Each is of 15 tons per hour capacity.

Figure 5 shows the entering side of the 110 in. mill, now used as a roughing stand. The top and bottom rolls are of 36 in. diameter. The middle roll is 24 in. in diameter. All of the rolls have a body length of 110 in. The roll neck bearings are of babbitt with brass inserts. The top and bottom rolls are driven through spindles and a three-high pinion stand.

The maximum rolling speed of the roughing stand is 460 feet per minute. Separate 500 psi hydraulic accumulator systems are used for operating the middle roll and for balancing the top roll and tilting tables. Reversing tilting roller tables on each side of the mill convey the slabs into the bottom and top roll passes. This mill is driven by a 4000 hp, 82 rpm, 3 phase, 60 cycle, 6600 volt, slip ring induction motor. Maximum

Figure 6 — The new 140 in. four-high stand, located 100 ft from the three-high stand, serves as a finishing stand, and is arranged for broadside rolling if desired.

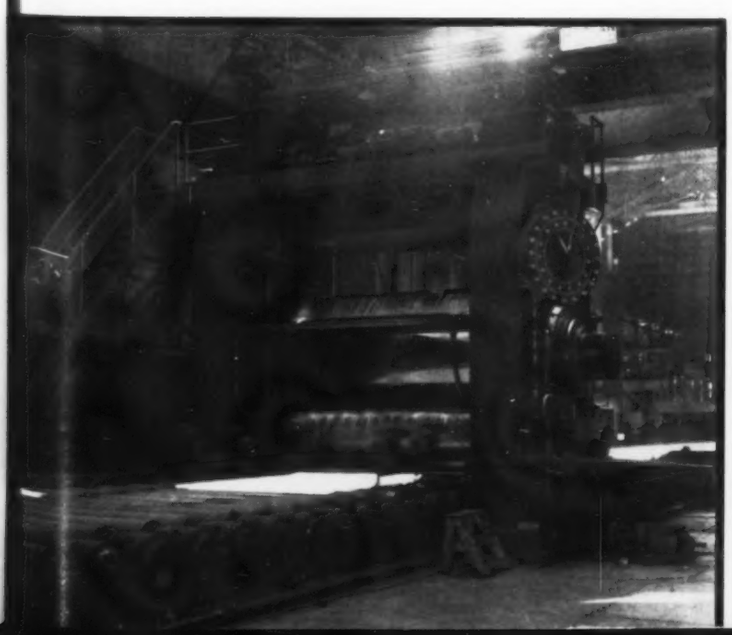
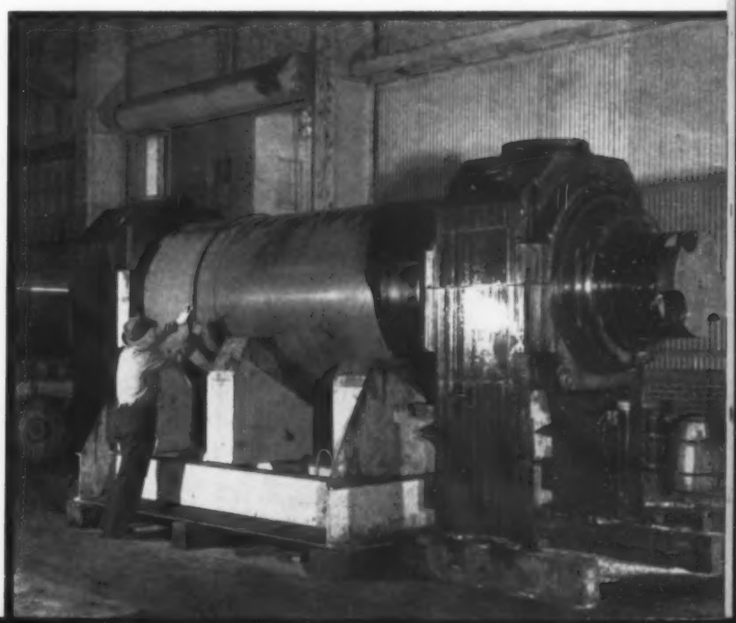


Figure 7 — Back-up roll assembly for the 140 in. mill, with oil film bearings.



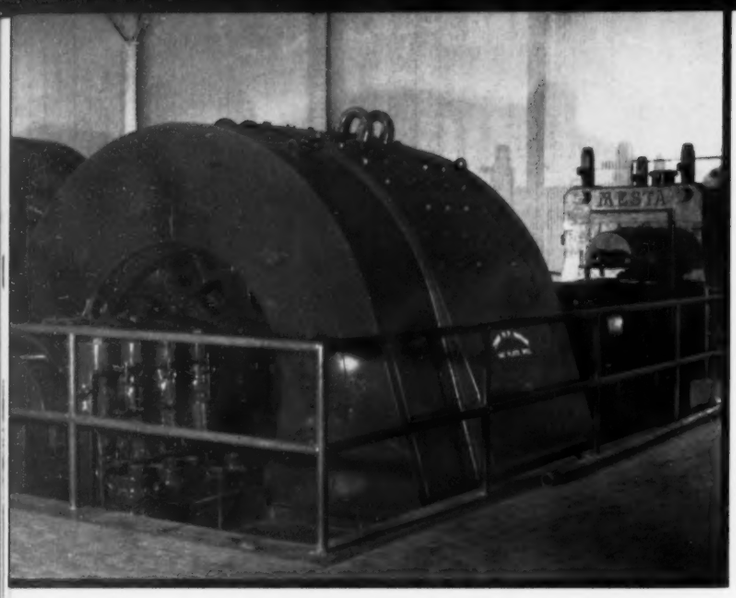


Figure 8 — The new four-high mill is driven by a 7000 hp, 35-70 rpm, 700 volt d-c reversing motor.

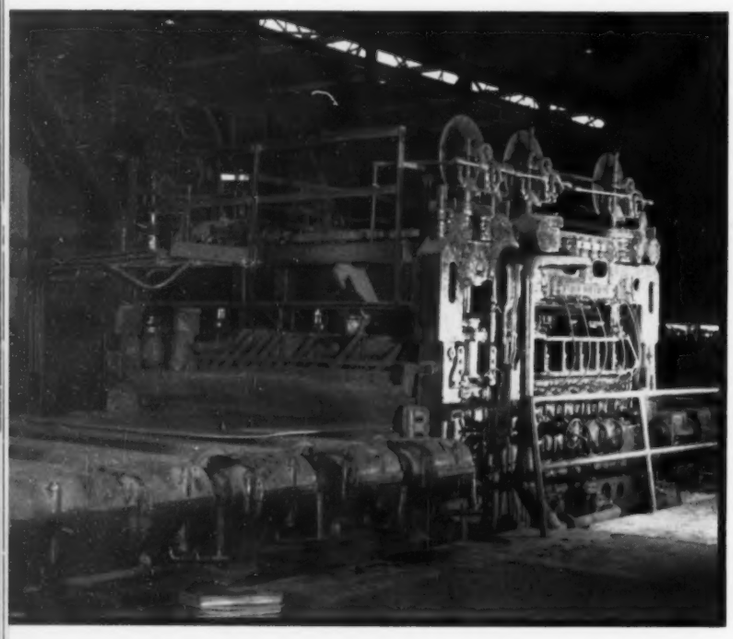


Figure 9 — This 12 in. x 140 in. two-high roller leveler, for thicknesses from 3/16 in. to 3/4 in., takes plate direct from the finishing stand.

running torque of this motor is approximately 700,000 lb-ft. A 22 ft diameter flywheel is provided between the motor and mill pinion stand.

The slab is reduced in thickness approximately 83 per cent on this mill. An average of 13 passes are now used for this reduction. This mill is being equipped with 1500 psi water descaling sprays to assist in removing the scale from the slabs.

After leaving the 110 in. mill the slab is conveyed over roller tables through 1500 psi water descaling sprays to thoroughly clean the slab before entering the 140 in. four-high reversing plate mill. A hydraulic system with a pneumatic accumulator supplies the requirements for the descaling sprays.

Figure 6 shows the entering side of the 140 in. stand. This mill reduces the average slab into finished plates in approximately 5 passes, with an average reduction of 50 per cent in thickness. It is located 100 ft from, and in line with the three-high mill. It has two 38 in. diameter work rolls and two 56 in. diameter back-up rolls, all having a body length of 140 in.

The work rolls are driven through spindles from a two-high pinion stand. The top and bottom back-up rolls are rotated by frictional contact with the work roll faces. Hydraulic pressure is used in addition to the roll weights to provide pressure between the rolls to insure rotation of the back-up rolls.

The work roll speed is variable up to a maximum of 600 feet per minute. The average rolling speed is approximately 450 feet per minute.

Tapered roller bearings are provided on the work roll necks and oil sleeve bearings on the back-up roll necks. The top back-up roll and top work roll are balanced by 3900 psi constant hydraulic pressure supplied from an accumulator system.

The top and bottom back-up roll assemblies are removed from the mill with a motor-driven roll changing rig. The work rolls are removed by a C-hook attached to the mill crane. Front and back reversing tables convey the slab to and from the mill. Motor-driven side guards are provided on the front table for squaring the slab. A tapered roll turn-around on the back table broadsides the slab when rolling plates over 96 in. wide. Automatic lubricating systems are provided for the mill and equipment.

Figure 7 shows a close-up view of one of the back-up roll assemblies for this mill. Its weight is approximately 100 tons.

Figure 8 is a view in the motor house showing the 140 in. mill motor and pinion stand. This mill is driven by a 7000 hp, 35/70 rpm, 700 volt, variable speed d-c reversing motor, having a continuous full load torque rating of 1,050,000 lb-ft at 35 rpm and 625,000 lb-ft at 70 rpm. Maximum full load torque of 2,362,000 lb-ft at 33.2 rpm. Maximum circuit breaker torque at 32.5 rpm is 2,887,500 lb-ft. Minimum reversal time at 35 rpm is two seconds, at 70 rpm, five seconds. Power is supplied to this motor by a variable voltage generator set consisting of two 3000 kw, 700 volt, 352 rpm, d-c gen-

←

Figure 10 — This 18 in. x 140 in. leveler is located in a table paralleling the mill line, and takes plates 3/4-1 1/4 in. in thickness.

erators, one 6000 hp, 352 rpm, 6600 volt, 3 phase, 60 cycle wound rotor induction motor, and with a steel plate flywheel 180 in. in diameter having 175,000 hp seconds stored energy at 360 rpm. Excitation is furnished from a six-unit exciter motor generator set.

This equipment is located in an extension to the old 110 in. mill motor house. The motor and generators are cooled with a "down draft" ventilation system in which cold air is drawn from the room through the motor and motor generators by fans. The heated air is cooled with heat exchangers and is then forced back into the motor room by the fans. Approximately 128,000 cfm of air is circulated through these units.

The fan units are located in the basement. The motor house atmosphere is maintained under a slight pressure. Clean outside make-up air is supplied to the room by a 25,000 cfm fan unit arranged with an electric precipitator unit for removing the dirt. Heat exchangers are used for cooling the air below the dew point and removing the moisture.

The mill screwdown motors and the front and back table motors operate on the "shovel" type variable voltage system from power supplied by a motor generator set made up of one 900 hp, 1200 rpm, 6600 volt, 3 phase, 60 cycle, a-c induction motor, and four 150 kw, 250 volt, d-c shovel type generators.

Power for the 140 in. plate mill is supplied by three 5000 kva, 44,000/6600 volt, 60 cycle transformers. The a-c auxiliary motors obtain their power from three 500 kva, 6600/240 volt transformers. Power for the 230 volt d-c auxiliary motors is supplied by two 1000 kw synchronous motor generator sets.

The finished rolled plate is conveyed from the 140 in. mill over roller tables to an eleven-roll, two-high roller leveler shown in Figure 9. This leveler has a capacity for leveling hot plates from 3/16 in. to 3/4 in. in thickness. The rolls are 12 in. in diameter x 140 in. long, and have a speed of 100 to 300 feet per minute. The leveler is equipped with a motor-driven screwdown, hydraulic top roll balance, and entering pinch rolls. A 125 hp, 300/900 rpm, 230 volt, d-c motor drives the rolls.

Following the leveling operation, the plates are transferred onto a grid type cooling bed, 90 ft wide and 78 ft long. The bed is composed of two sections, each section is equipped with three separately driven sets of transfer chains provided with a series of dogs to engage and slide the plate across the bed. The bed can be operated as two separate units handling plates up to 45 ft long, or as one unit for handling longer plates. The plates are delivered from this bed over a roller table to a nine-roll. two-high roller leveler shown in Figure 10. This leveler has a capacity for leveling hot plates from 3/4 in. to 1 1/4 in. in thickness. The rolls are 18 in. in diameter x 140 in. long, and the speed is 100 to 300 feet per minute. The leveler is equipped with a motor-driven screwdown, hydraulic roll balance and entering pinch rolls. A 350 hp, 300 to 900 rpm, 230 volt, d-c motor drives the rolls. Plates less than 3/4 in. in thickness previously leveled on the lighter machine are idle-passed through the 18 in. leveler.

Figure 11 — The front end of the plate is cropped in this down-cut shear before proceeding to a rotary side shear.

Figure 12 — Two end shears, of down cut type, cut the plates to desired lengths after they have been side trimmed.

→

Figure 13 — Low head gantry cranes equipped with magnets handle plates from the runout table or from castor beds.

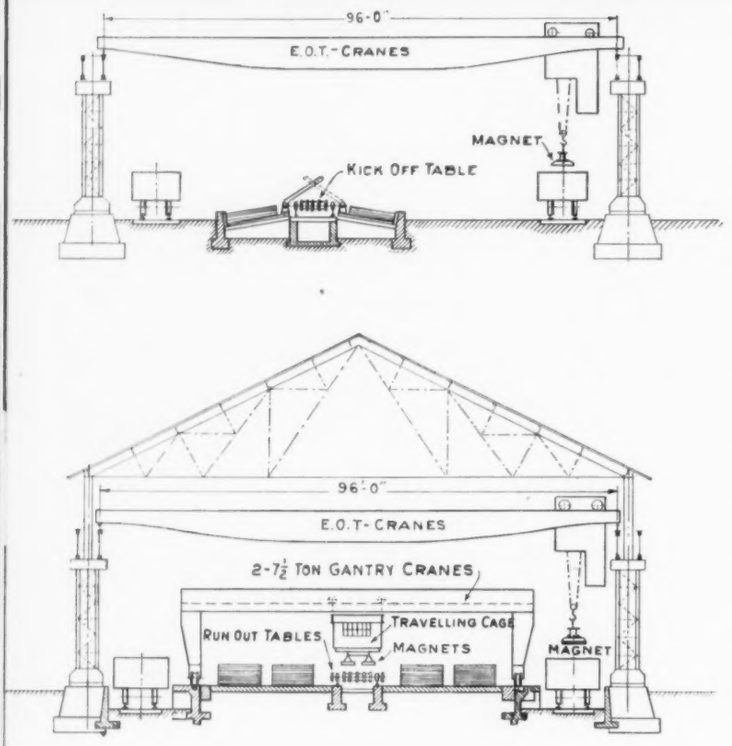


Figure 14 — Sections through the shipping runway before (top) and after (bottom) remodeling.

After passing through the leveler the plates are conveyed over a roller table, from which the flow of plates is diverted into two paths. All plates up to 1 in. in thickness and lighter, and up to 120 in. wide, are transferred to another cooling bed 60 ft wide and 78 ft long for further cooling. This bed is similar to the other bed except for direction of travel, and operates as a single section. Plates over 1 in. in thickness and over 120 in. wide are carried forward over a chain conveyor to plate burning beds, or to a 190 in. side shear.

The plates conveyed over the second cooling bed are transferred on a roller table to a down-cut shear shown in Figure 11. This shear crops the front end of the plate and the plate then enters the side trimming rotary shear, which shears the plate to width. The crop and rotary shears were utilized from the 110 in. mill and remained in the same location for the 140 in. mill.

The rotary shear entry table is equipped with electromagnets to align and assist in feeding the plate into the rotary shear knives. Two sets of circular revolving knives are used for trimming each side of the plate, one set is adjustable for various widths. This unit has a shearing capacity up to 1 in. in thickness, 36 in. to 120 in. in width, and operates at speeds from 82 to 164 feet per minute. Rotary driven scrap shears are provided for shearing the side scrap into short lengths suitable for handling. Motor-driven adjustable side guards on the back table hold the plate in line while being side trimmed.

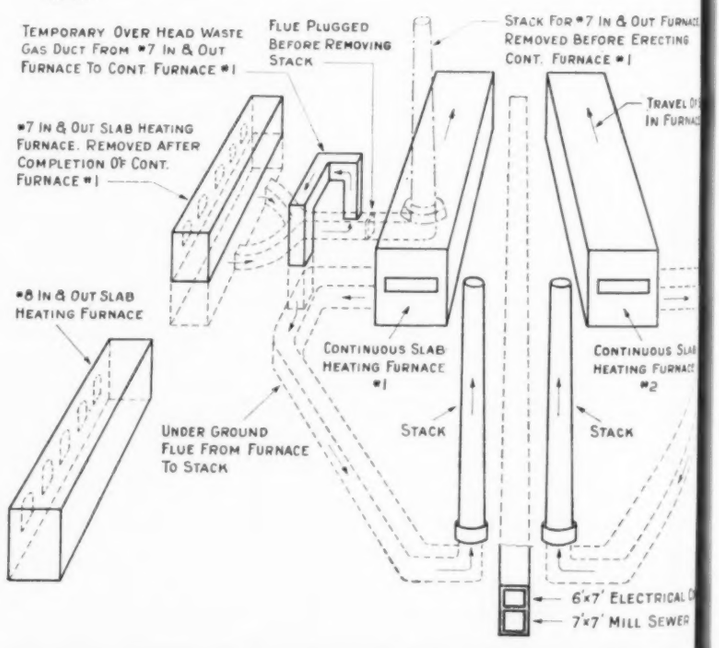
After the plates are side trimmed they are transported over roller tables to a cable driven dog type transfer bed where the plates are again diverted into two paths, each leading into an end shear for shearing to length. Both shears are of down-cut type. Figure 12 shows the exit from these shears. The plates are conveyed from the shears over roller tables to two other cable-driven dog type transfer beds, or to an underslung type crane equipped with magnets which transfer them to a 190 in. side shear for shearing into smaller plates.

The two transfer beds convey the finished plates from each end shear into a single flow line. Plates from the side shear are returned over castors to one of the transfers. The plates then pass over an inspection tilter, where they are checked for size and inspected for defects. The plates are then transported over roller tables extending through the shipping runway, shown in Figure 13.

Plates are removed from the tables by two 7½ ton low head gantry cranes equipped with magnets. These cranes operate the full length of the runway underneath the overhead cranes. They remove the plates from the tables and place them into assorted stacks on either side. The stacks of plates are handled by overhead cranes to platform scales for weighing and loading into railroad cars on depressed tracks. Figure 14 shows typical cross sections of the shipping runway before and after remodeling.

This mill is provided with a roll shop equipped for turning and grinding the mill rolls. A 72 in. roll lathe and a 60 in. roll grinder were added for turning and grinding the 140 in. mill rolls. A gasoline driven car is used for transferring the rolls to and from the mill. A new pump house has been added for housing the descaling and the 110 in. mill roll balance pumps. The lubricating systems and other 140 in. mill pumps and accumulators are located in the mill and motor house basements.

Figure 15 — Diagrammatic sketch showing how new furnaces were built while old furnaces continued operation.


TEMPORARY OVER HEAD WASTE GAS DUCT FROM #7 IN & OUT FURNACE TO CONT. FURNACE #1
FLUE PLUGGED BEFORE REMOVING STACK
STACK FOR #7 IN & OUT FURNACE REMOVED BEFORE ERECTING CONT. FURNACE #1
#7 IN & OUT SLAB HEATING FURNACE. REMOVED AFTER COMPLETION OF CONT. FURNACE #1
#8 IN & OUT SLAB HEATING FURNACE
CONTINUOUS SLAB HEATING FURNACE #1
CONTINUOUS SLAB HEATING FURNACE #2
UNDER GROUND FLUE FROM FURNACE TO STACK
STACK
STACK
6'x7' ELECTRICAL
7'x7' MILL SEWER

The connected load of motors for the 110 in. mill before remodeling was

4000 hp at 6600 volts, a-c
1680 hp at 220 volts, a-c
2122 hp at 230 volts, d-c

7802 hp — grand total

The connected load of motors exclusive of the motor generator motors for the 140 in. mill after remodeling is

4000 hp at 6600 volts, a-c
2500 hp at 220 volts, a-c
7000 hp at 700 volts, d-c
7440 hp at 230 volts, d-c

20940 hp — grand total

PROBLEMS ENCOUNTERED IN ERECTION

Many engineering, construction and operating problems were encountered in remodeling the mill. It was imperative that the revamping of this mill be done with the minimum of interference with production, requiring very close co-ordination between the engineering, construction shops and operating departments. Starting at the slab heating furnaces it was necessary to erect the new furnaces while maintaining operations on the old in-and-out furnaces. Figure 15 shows a diagrammatic layout of the old and new furnaces. The stack from No. 7 in-and-out furnace was located on the site of No. 1 continuous furnace. This problem was solved by first erecting the new stack and flue of No. 1 continuous furnace. The gases from No. 7 furnace were bypassed through a temporary duct into the new flue after which the old stack was removed. An existing mill sewer prevented the furnace being located in a position to provide stack clearance.

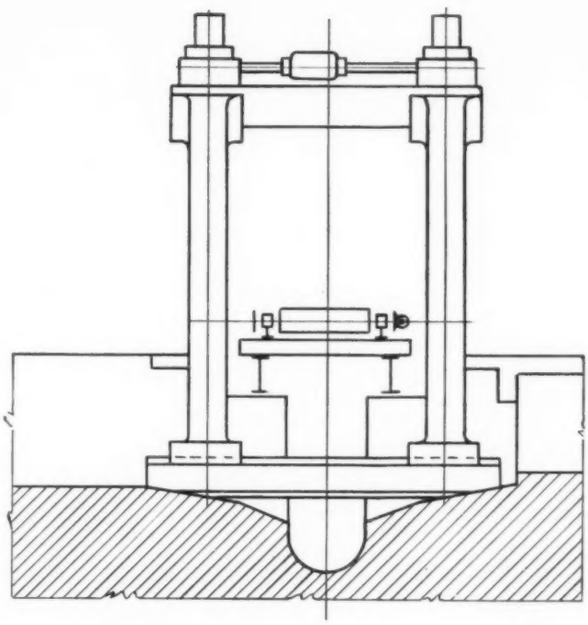


Figure 16 — Sketch showing 140 in. housings in place with old 110 in. tables supported on temporary beams. Excavation and foundations for the new mill were made while the old tables remained in operation.

Figure 17 — New mill housings were unloaded in flat position in the motor room, slid over, and upended on their shoes by overhead cranes.

The installation of the 140 in. mill introduced a number of major problems. This mill, being located in the flow line of the plates from the 110 in. mill, required the foundations to be completed and the mill erected except for the mill rolls without delaying production on the 110 in. mill. This was accomplished as shown in Figure 19. The old tables at the new mill were supported on temporary beams, thus permitting the excavation and foundations for the mill to be completed. The mill shoes were then installed. During one of the regular 24-hour weekly shut downs a section of the old table was temporarily removed to provide for installation of the mill housings. Due to the extreme height and weight of the mill housings, it was not possible to place them directly on the shoes with the crane. This was accomplished as shown in Figure 17. These housings were unloaded in the motor house in a flat position and were slid over and up-ended on the shoes in an upright position by the overhead cranes. After the housings were placed the old section of the table was re-installed.

The erection of the balance of the mill proceeded during operation of the 110 in. mill.

Figure 18 shows the foundations for the new tables, which extended for a distance of approximately 400 feet. The new tables, being wider than the old tables and conveyors, permitted the foundations to be placed without interfering with production. The tables were supported on temporary beams to permit portions of the old foundations to be removed where necessary.

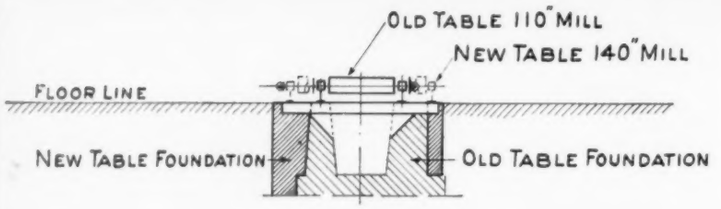


Figure 18 — New foundations were installed outside of existing table foundations while the old tables remained in operation, supported by temporary beams.

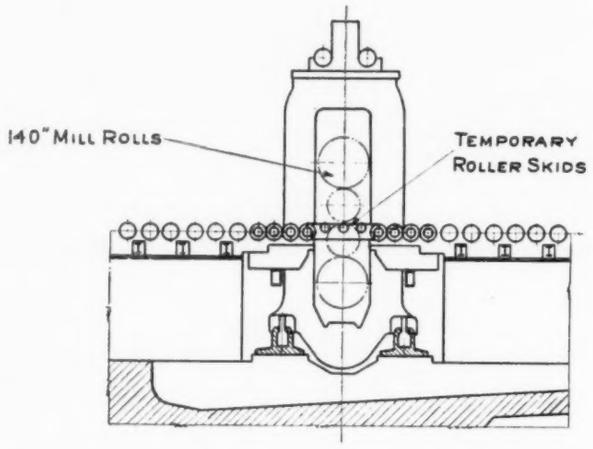


Figure 19 — Temporary roller skids carried the plate through the new 140 in. stand after its installation until it was ready for operation.

The old tables were later removed and the new tables erected in progressive stages toward the shipping end, utilizing the regular weekly 24-hour shut down for this work, except for the front and back 140 in. mill tables, which required an additional 24-hour shut down on the mill.

Figure 19 shows temporary roller skids that were installed between the tables at the mill to carry the plates over this gap later occupied by the mill rolls.

The new 12 in. leveler was located in the old chain cooling conveyor line. The leveler foundations, drive and shoes were installed with the conveyor in place. During one of the shut downs, the tail shaft of the conveyor was moved ahead to the exit side of the leveler. The housings and bottom bank of rolls were then installed, permitting the rolls to be temporarily used as a table for conveying the plates. The remainder of the leveler, including the top bank of rolls and screwdown, were later erected and the leveler was placed in production. The existing leveler was then removed and replaced with the new roller table occupying its site.

The cooling bed tables between the new leveler and the 156 in. end shear were then installed progressively during regular 24-hour weekly shut downs on foundations previously completed. A section of the existing conveyor and the tail shaft was relocated each time a new section of table was installed.

In order to expedite the completion of the tables they were previously assembled in sections near their site, permitting them to be placed on their foundations in the least possible time. The installation of the cooling beds, east tables, and the 18 in. x 140 in. leveler proceeded uniformly during their erection. This equipment, not being in the flow line from the old mill, required no special erection methods.

The next major problem involved the rearrangement and additions to the end shear equipment to maintain production while this equipment was being installed. This work was accomplished in the following manner:

The east shear line, consisting of the new end shear and four tables, was installed outside of the regular flow line except for a short section of table occupied by the 190 in. side shear. When this was nearly completed the side shear was relocated to its permanent position in another runway. After this installation was completed the plates were diverted from the existing line and were sheared on the new line, permitting the old line to be abandoned for erection of the west line, including the south transfer beds, inspection tilter, and the relocated old end shear. The finished sheared plates from the east line were conveyed into the runway over castor beds and were handled by cranes from that point until completion of the south transfers.

The runout tables south of the inspection tilter were obtained from existing tables originally used throughout the old mill, except for a new conveyor section on the south end.

A number of other difficulties in maintaining production were encountered which involved changes and additions to tracks, building additions and alterations, pipe lines, sewers, electrical feeders, wiring, pumps, accumulator, shears, scales and other items, each developing considerable engineering and construction problems which were required to be solved before attempting the actual work.

Original estimates indicated that it would be necessary to shut down operations of the 110 in. mill a total of about one month for installing the new equipment.

The entire job of remodeling was completed with an actual loss of only 30 hours and 45 minutes of possible rolling time on the 110 in. mill. Instead of losing one month's production as originally expected, all previous tonnage records were broken on the old mill while the new mill was under construction.

DISCUSSION

PRESENTED BY

R. R. THOMAS, Assistant Chief Engineer, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama.

E. CALDWELL, Assistant Chief, Bureau of Steam Engineering Department, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama

E. A. HAWK, Fuel Engineer, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama

C. W. HARRISON, Chief Electrical Engineer, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama

M. P. MELLON, Superintendent Construction, Manufacturing Division, Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama

R. R. THOMAS: The major units that were installed on this project are of modern conventional designs without any unusual features. Due to limited available space and head-room, special designs and arrangements were required for some of the auxiliary equipment including roll changing devices, cooling beds, shearing lines and shipping facilities.

Considerable engineering study and planning was involved in providing for the installation of foundations, removal of old equipment and erection of new equipment with the minimum of interference of operation of the old mill. As a result of the combined effort and cooperation of the operating, construction, maintenance, shops and engineering departments, the loss in operating time of the old mill during the change-over was reduced to about 5 per cent of that originally estimated.

E. CALDWELL: The heat generated by the various electrical units is dissipated by means of finned coils which cool the air in each of the "down-draft" ventilating systems for the 7,000 hp motor and the motor-generator set. The combined circulating capacity is approximately 128,000 cfm.

The coils are supplied with 50 F water from the Birmingham industrial system, so piped that the water used for the two hydraulic systems is first taken through the coils under pressure before going to the pumps, the water thus serving a two-fold purpose.

This arrangement is also desirable from a standpoint of control due to the fact that the hydraulic systems operate only when the mills operate, thus creating a circulation of water through the finned coolers only when the mill motors are in operation.

The air leaving the coolers is reduced to a temperature of about 60 F before being delivered by the recirculating fans into the motor room.

The atmosphere in the motor toom is maintained at a temperature of about 75 F during the summer months.

To maintain the motor room atmosphere free from dust and smoke, a 25,000 cfm outside air make-up system was installed. It is equipped with an electric precipitator for cleaning the air and a finned coil for pre-cooling the air below the dew point so that condensation of the atmospheric moisture does not take place in the recirculating system serving the motor-generator sets referred to above.

The make-up air is delivered into the motor room by a pressure fan which maintains the motor room atmosphere under sufficient pressure to prevent dust from the outside finding its way into the motor room through cracks or when any of the service doors are opened.

Normally the 25,000 cfm make-up air finds its way out of the motor room through wall cracks and unavoidable small openings and maintains a pressure of about ¼ in. water pressure in the motor room.

The descaling system consists essentially of two motor driven horizontal duplex hydraulic pumps, supplying water at 1,500 psi to the spray header through a 6 in. double extra heavy line on which is by-passed a pneumatic accumulator 39 in. inside diameter and 23 ft high, having an available water storage capacity of 250 gallons.

Each hydraulic pump is equipped with an automatically controlled unloading valve installed in the discharge line of the pump, which when unloaded allows the discharge to recirculate to the suction of the pump and a check valve to prevent line pressure building-up in the pump.

The unloading valves are actuated by electrical pressure switches connected to the air space of the pneumatic accumulator, through solenoid operated air valves and air cylinder to load and unload the pumps automatically at 1,475 and 1,500 psi respectively.

The pneumatic accumulator is connected to the supply main at a point near the sprays by a 6 in. line in which is installed a quick acting air operated cut-off valve actuated by a liquid level controller attached to the accumulator. It is designed to automatically close the cut-off valves at a predetermined low water level in the accumulator to prevent the loss of high pressure air out of the accumulator.

When the pressure in the supply main exceeds the pressure in the accumulator the cut-off valve is automatically opened by means of a differential pressure regulator.

The high pressure air in the accumulator is supplied by a manually controlled motor driven two-stage air compressor with intake air from the 100 lb plant system. About 3½ hours is required to fill the accumulator to the desired air pressure.

The normal loss of air is replaced intermittently, which requires running the compressor about 30 minutes every two or three days.

The two spray headers, one above and one below the roll table, are each equipped with 30 high pressure spray nozzles.

Each spray nozzle has a capacity of 30 gpm at 1,500 psi which means that the entire spray system requires water at the rate of 1,800 gallons per minute or 30 gallons per second.

The maximum available water capacity when operating one pump is 200 gpm or 3.33 gps from the pump and 250 gallons from the accumulator.

Deducting the 3.33 gps from the 30 gps required leaves 26.67 gps to be drawn from the accumulator requiring 250 ÷ 26.6 or 9.4 seconds, which is the maximum sustained spraying time possible when operating one pump.

Two pumps operating would supply 6.66 gps, leaving 23.34 gps to be supplied by the accumulator, requiring 250 ÷ 23.34 or 10.7 seconds which is the maximum sustained spraying time possible when operating two pumps.

The minimum time required to replace the 250 gallons drawn from the accumulator would be 250 ÷ 3.33 = 75 seconds operating one pump or 37.5 seconds operating two pumps.

This means that the minimum cycle or time between sprays would be 75 plus 9.4 = 84.4 seconds when operating one pump, and 37.5 plus 10.7 = 48.2 seconds when operating two pumps.

As the average rolling speed of the mill is 450 fpm or 7.5 fps, it would require a plate 60 ft long 8 seconds to pass under the sprays, which is well within the maximum spraying time of 9.4 seconds when operating one pump.

The sprays employed for this use produce a flat spray

and are set to impinge upon the plate at a slight angle from the vertical toward the approaching plate. By this means the spray tends to dig under the scale and actually peels the scale from the plate. If the nozzles were set at right angles to the plate there would be a tendency to drive the scale into the metal, consequently complete removal of the scale would not be accomplished.

The centers of the nozzles are aligned at right angles to the plate travel but each nozzle is turned about 5 degrees on its center so that the edges of the sprays overlap slightly at the point of impingement without striking each other.

Should the edges of the sprays strike one another the resultant force of the sprays would be greatly reduced and a streak of unremoved scale would be observed on the entire length of the plate.

The valves controlling the water to the sprays are also of the quick acting type actuated manually from the pulpit by a foot operated electric switch.

To relieve the shocks resulting from the quick opening and closing of the various valves referred to above, two spring opposed shock alleviators are placed on the supply main immediately preceding the cut-off valves to the spray headers.

E. A. HAWK: In the early continuous type of reheating furnaces the flame travel was counter to the travel of the material being heated. Later, this design was modified by installing a primary heating zone closer to the charging end and using the balance of furnace as a soaking zone. With this design it was possible to transfer heat at a faster rate to the steel without overheating.

On the new plate mill furnaces, the main burners are located at the charging end, the flame and steel traveling in the same direction. In this design, the transfer of heat to the steel is still greater without overheating. When the steel reaches the soaking hearth, it has obtained its maximum heat and needs only time for eliminating cold skid marks to obtain uniform temperature. In other words, for the same thickness of steel and rate of production, the length of furnace need not be as long for this design.

The main temperature control couple is located just beyond the approach to the soaking hearth as the steel at this point should not gain nor lose heat. When there is still a demand for heat at this point, and overheating or sweating may occur closer to the charging end, then the only expedient is to increase the air-gas ratio if air is available or develop a softer flame. A lower furnace pressure will also correct this condition.

At the discharge end, the waste gases from the firing zone are returned under the soaking hearth to the recuperators. Sufficient furnace pressure is maintained to reduce air infiltration around the discharge doors. A higher preheat is possible on this type of furnace compared to the conventional design on account of the high waste gas temperature entering the recuperators. Incidentally, as there is no vent for release of waste gases, flues and stack must be designed for the maximum firing rate.

A safety feature is an automatic gas shut-off valve in case of power failure on the motor driven fans supplying combustion air.

To facilitate repairs to the hearth over week ends it is best to finish up with light slabs. Build-up in slab weights should be gradual. Peak loads may occur two or three times a week. Change in slab thickness should be limited to about 2 inches.

An auxiliary gas burner has recently been installed on each side of both furnaces at the mid point of the soaking hearth. These burners take the place of the mill delay burners and act as a booster to maintain temperature on the soaking hearth. They are under full automatic temperature control. Scale loss is low, and hearth build-up is below average.

C. W. HARRISON: Mr. Clark has covered the electrical features of the 140 in. plate mill so well that little need be added to his description of the main equipment. However, a few details may be of interest.

The addition of the plate mill made necessary a reshuffle of the load on our principal transformer station at the Fairfield Steel Works. A new bank of 44000/6600 volt transformers was purchased and used to replace an existing bank of 15000 kva transformers which had been overloaded. The 15000 kva bank thus released was used to feed the plate mill as well as part of the other load at the Fairfield Steel Works.

The plate mill load is carried through three conductor cables underground from the transformer station. An outdoor oil circuit breaker protects these cables, which terminate at the plate mill motor room in a ten unit metal-clad switchgear of the air break type. Current limiting reactors are used in this circuit to limit short circuit values to a point below the rating of the metalclad breakers.

This switchgear controls all 6600 volt circuits for both the 110 in. plate mill and the new 140 in. mill. Included are primary forward and reverse breakers for the 4000 hp 110 in. mill motor, primary and dynamic braking breakers for the 6000 hp motor for the 140 in. mill main motor generator, breakers for across the line starting of two 1450 hp and one 900 hp motor for auxiliary motor generator sets and breakers for two 6600/240 volt transformer banks, one for auxiliary motors and one for lights.

Three different types of Ward-Leonard control are used in connection with the 140 in. plate mill. For the 7000 hp main drive, the flywheel motor generator set supplying power to a d-c motor was the obvious answer. With this arrangement a relatively small a-c motor, with a large flywheel to help carry the peaks, drives generators capable of developing enormous power for short periods. In no other way is it possible to get as smooth a reversing control with so little disturbance to the power system.

The shovel type generators, mentioned by Mr. Clark in connection with the mill screwdown and front and back table drives, are part of another Ward-Leonard system. All drive motors are 75 hp, 500 rpm, 230 volt d-c shunt wound mill type. Two motors, operating in parallel from one 150 kw generator, drive the screwdown. Similarly, two motors drive the front table and two drive the back table, each pair having their own generator. All generators are driven by the same motor and are of the three field differentially compound wound type. With this arrangement, the motors when lightly loaded are given high voltage with resulting high speed. With heavy load the generator voltage droops sharply causing the motors to slow down but allows them to

develop maximum torque up to their safe current capacity. This is true even in a stalled condition.

A simpler form of Ward-Leonard system is applied to the plate inspection table. Here the plate is tilted and the inspector walks in between the rolls to examine the under side of the plate. For this reason, each roll is separately driven by a gear motor, there being a total of twenty. Due to the fact that the duty was expected to be severe with frequent starts, stops, and reversals and because the number of motors involved made it economically feasible, the Ward-Leonard system was chosen. The twenty d-c gear motors are connected to a common bus and fed from a 40 kw, 125 volt d-c generator. All motors are controlled by a common master switch which enables all to be started, stopped, or reversed simultaneously.

Mr. Clark mentioned the fact that it was not an easy matter to keep the old mill running while the new mill was being installed. The electrical construction involved many problems in this connection. Much temporary wiring and many make-shift schemes were resorted to when it became necessary to move a great deal of operating equipment to make room for new construction.

M. P. MELLON: I was employed in the field engineering department in 1917 when the foundations for a proposed second mill were constructed on the present site of the new 140 in. plate mill. One interesting thing we found in demolishing the old foundation was that the old foundation bolts, which were encased with terra cotta pipe packed with grease, were in perfect condition after being buried for twenty-five years.

In extending the present 110 in. mill motor house, the basement was made four feet deeper than the old basement. This necessitated removing the adjacent main plate mill building column foundations. Since the span was 20 feet, old 40 foot girders were used for shoring up building and removing alternate piers and in this manner all piers were reconstructed without interference to operation.

The two new plate mill reheating furnaces were built over a double box 7 ft x 7 ft sewer, the lower section carrying storm and mill water, the top section, electric cables. There was also on the site of No. 1 reheating furnace, a 150 foot steel stack serving old No. 7 in-and-out furnace, as well as several water and gas lines. The stack was removed and by an ingenious method of tying the flues to new stack, the old furnace was operated until No. 2 reheating furnace was built and put in operation.

During the job we had a considerable turn-over of men due to joining the armed forces, but in spite of all that, we had no serious lost time accidents to our forces.

Before the job began it looked almost hopeless at times as to how we were going to do the work with the mill in operation. In constructing the foundations for new tables, men worked around and under the old tables, cutting concrete, installing new foundations and, in fact, we blasted the very legs from under the old mill from one end to the other. Old corrugated iron sheets were erected over men under the tables, while they worked around the clock, to prevent hot scale from burning them.

The roofs over the plate mill and shipping building were replaced, old type monitor sash dismantled and new skylights, roof and ventilators erected while the mill was in operation.

Over the week-end new tables and equipment, which had been assembled on floor parallel to old tables on timbers and greased rails, were slid and wrestled into place by Monday morning ready for operation.

In this work we excavated approximately 66,000 cubic yards of rock, old concrete and dirt, placed 19,000 cubic yards of new concrete foundations. New structural steel erected amounted to 2,400 tons. There were about 2,500 tons of new equipment placed. The mill housings weighed 130 tons each and were 30 feet high. Other heavy pieces were the 178,000 lb flywheel for the motor generator set, and the pinion stand which weighed, without cap, 200,000 lb. All were handled by 50-ton overhead cranes together with hoisting engines. The new 75-ton mill crane did not arrive on the job until most of the heavy pieces were in place.

Only through the close co-operation and collaboration of field and operating forces was this job successfully carried to a conclusion.

Voltage Drop IN A-c Collector Systems FOR Cranes AND Bridges

. . . . setting forth the design of a-c collector systems, with calculations for voltage drop . . . .

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▲ POWER to cranes and material-handling bridges is transmitted by means of systems of rails or trolley wires with collector shoes or wheels on the movable structures and with incoming power connections made at suitable points along the collector systems. Each crane or bridge supports a movable carriage which moves in a direction at right angles to the motion of its supporting structure. Another collector system is provided on the structure for supplying power to the movable carriage.

The majority of collector systems are for d-c power; however, a considerable number transmit a-c power. Alternating current may be used for drive and hoist motors or for motor-generator sets providing adjustable voltage d-c power for d-c drive and hoist motors. Figure 1 shows a typical bridge using a-c power.

A collector system for three-phase a-c power will usually consist of three steel rails or angles with copper wires or cables tapped into the steel conductors at suitable intervals. It has been found that the use of steel conductors for contact with the moving collector shoes or wheels eliminates much of the maintenance expense incident to use of copper trolley conductors.

The operating voltage of such systems will usually be 220, 440 or 550 volts, depending primarily upon the sizes of motors used, and on safety requirements.

In order for the hoist and drive motors to have sufficient torque, the voltage drop in the collector system must not be excessive; hence the systems should be designed and constructed in such a way that voltage drop is kept to a practical minimum.

The importance of minimizing voltage drop is illustrated by a recent unfortunate experience with an improperly designed a-c collector system. This system utilized three steel rails along the length of an overhead runway for a bridge straddling a large ore pile. No copper conductors paralleled the steel rails. Power was supplied at one end only. When the bridge was first started, it happened that it was situated at the power supply end of the collector system. The owners were pleased to see that the bridge started satisfactorily and ran successfully to the end of the runway. However, when the operator attempted to start the drive motor to return the bridge to the power supply end, it failed to move. The voltage drop in the collector system was so great that the motor could not draw enough starting current to begin moving. The bridge was then ignominiously returned to the starting point by the use of some heavy ropes and a large number of mules.

When the collector rails were later supplemented by a three-conductor cable, good performance was obtained and that bridge is now handling large quantities of ore without any help from the mules.

The voltage drop in a-c collector systems includes not only a resistance drop but also a reactance drop, the latter being absent in d-c collector systems. By proper design, however, it is entirely feasible to keep the voltage drop in a-c collector systems well within the requirements of satisfactory operation of the cranes and bridges on which they are used.

The voltage drop which is permissible is usually determined by the requirements of the motors operating on the movable part of the crane or bridge. At the time of delivery of maximum current it is usually permissible for the voltage to fall to a value 10 per cent below the motor rated voltage. Since the no-load volt-

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age may be as much as 10 per cent above motor rated voltage, a maximum total drop of 20 per cent may therefore be permissible. In most cases much better regulation can be obtained. Lighting requirements may in some cases demand a smaller voltage variation in order to give satisfactory illumination. The drop in the collector system is, of course, only a part of the total drop.

The data given in this paper permit determining the voltage drops in a-c collector systems under varying conditions with a view to the selection of systems with desirable characteristics.

This information was obtained from laboratory tests, from calculations, and from measurements on an actual collector system for a material-handling bridge.

For a given load current, the principal design features affecting collector system voltage drop are as follows:

1. Number and size of conductors.
2. Length of collector system.
3. Spacing between phases.
4. Number and location of taps.
5. Relative position of steel and copper.

NUMBER AND SIZE OF CONDUCTORS

The number of conductors is usually six for three-phase power. That is, three steel conductors are paralleled by three copper conductors. Occasionally additional copper conductors are used.

The number and size of copper conductors is determined by current-carrying requirements and by voltage drop. Information on current carrying capacities of copper wires and cables is readily available to engineers who may be called upon to design collector systems. The information in this paper may be used to estimate the effect of copper conductors on voltage drop.

The size of steel conductors should be determined principally by consideration of expected wear, current-carrying capacity, and voltage drop. Specific data on wear and current carrying capacity of steel conductors is not generally available. Experience has indicated that the sizes employed in practice have been satisfactory in these respects. A lack of data on voltage drop in these conductors, however, has been a handicap to successful collector system design. It is for this reason that the investigation outlined in this paper was undertaken.

LENGTH OF COLLECTOR SYSTEM

The length of collector system which must be considered in estimating maximum voltage drop is not always equal to the length of the runway along which the conductors are placed. The effective length is influenced by the manner and locations for supplying power to the collector system. Several arrangements for power supply are shown in Figure 2.

The majority of systems will be supplied in the

Figure 1 — Bridge equipped with a-c motors and full magnetic control.

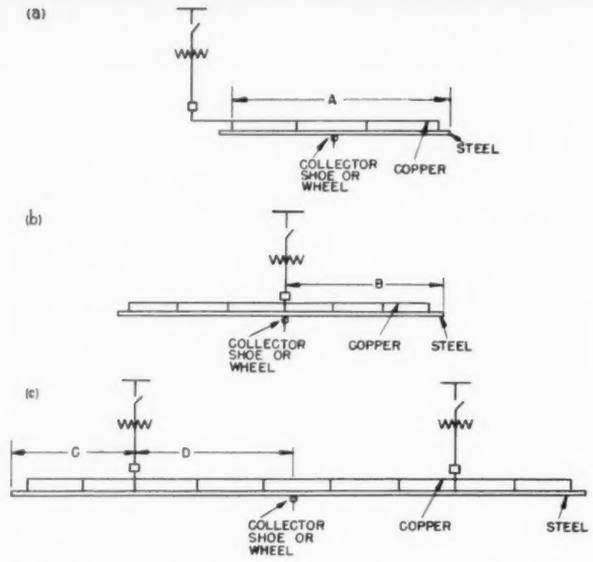
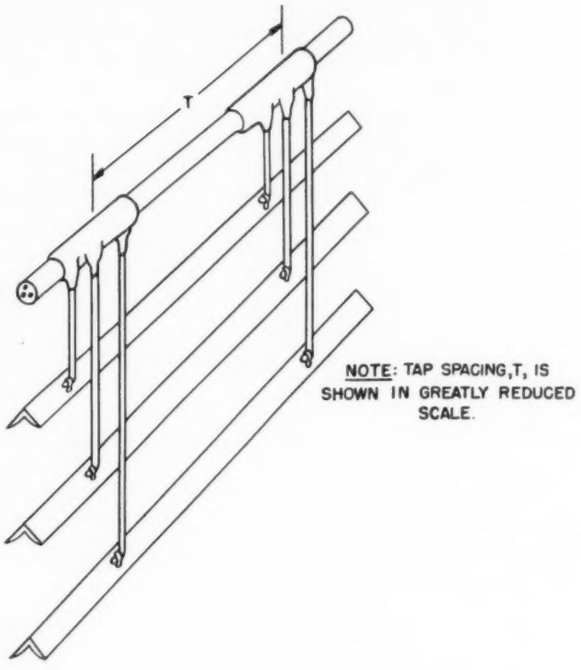


Figure 2 — Arrangements for power supply to a-c collector systems.

Figure 3 — A-c collector rail system showing effective use of paralleling copper conductors.



manner shown in Figure 2(a) where power is supplied at one end of the collector system. For this case the effective length is the total length, A, of the system, which is practically equal to the length of the runway.

For runways of unusual length, the arrangements of Figure 2(b) or Figure 2(c) are preferable.

In Figure 2(b) the length to be considered in estimating maximum voltage drop is the distance, B, from the centrally-located transformer bank to one end of the runway.

In Figure 2(c) there are two lengths which should be considered in estimating maximum voltage drop. One is the distance, C, from one of the two banks to the nearest end of the runway. The other is the distance, D, from one bank to the point midway between the two banks. For best design, D should be equal to approximately twice C so that the voltage drop is approximately the same whether the collector shoe is at the middle or at either end of the runway.

SPACING BETWEEN PHASES

When three conductors are used to supply 3 phase power, the reactance of the circuit can be reduced by reducing the spacing between the phases.

Hence the following two means are helpful in minimizing voltage drop in an a-c collector system:

1. Use of three-conductor cable for the copper conductors which parallel the steel rails or angles.
2. Use of the smallest feasible spacing of steel conductors, consistent with economical construction, adequate insulation, and convenient maintenance.

The use of the three-conductor cable, rather than single conductor cable or bare copper wires is very effective. For current of low power factor, the voltage drop in a three-conductor cable is approximately one-third of that of three copper wires spaced 12 in. apart. It is from 1/5 to 1/15 of that of steel conductors of the types and spacings studied.

Figure 3 shows a construction using a three-conductor cable for effectively reducing voltage drop.

The effect of reducing the spacing of steel conductors is shown by Figure 11. It should be noted that this

TABLE I

Circuit	Impedance, ohms per 1000 ft	A-c resistance, ohms per 1000 ft	Voltage drop per 100 ft for 500 amp, .8 pf	Watts loss per 100 ft for 500 amp
System of Figure 5	.120	.063	6.2	1570
500,000 cm copper, 18 in. spacing	.106	.020	5.5	500
500,000 cm, 3-conductor cable	.035	.020	1.8	500

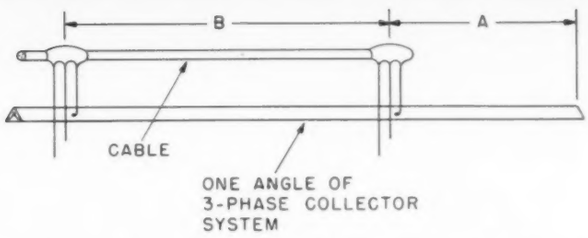


Figure 4 — A-c collector rail system showing location of taps near end of steel conductors.

figure shows the variation of impedance of the steel conductors only. For a collector system in which parallel copper conductors are used, Figure 11 illustrates the effect of steel conductor spacing on the drop in a section (between two taps) to a collector shoe within that section.

NUMBER AND LOCATION OF TAPS

As the spacing between taps in a collector system is reduced, the maximum voltage drop which can occur within a section is reduced, for systems of the type shown in Figure 3. This maximum drop occurs when the collector shoe or wheel is at a point approximately midway between taps.

The exact spacing to be used will depend upon local conditions. Figure 9 shows the voltage drop for a spacing of 50 feet. As the spacing is reduced, the voltage drop is lowered in almost exact proportion.

The spacing between the taps does not greatly affect

Figure 6 — Bridge and crane collector rails set up for electrical loss measurements.

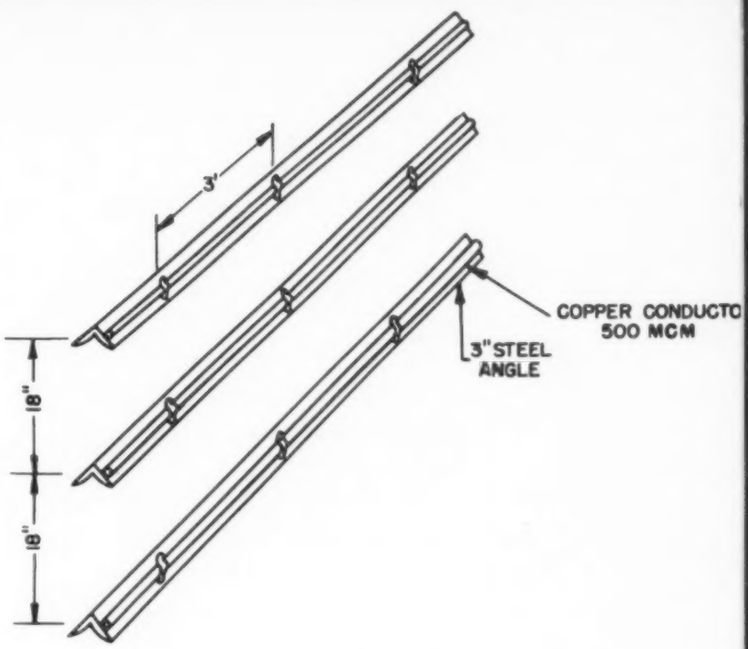


Figure 5 — A-c collector rail system showing ineffective use of paralleling copper conductors.

the voltage drop for a section when the collector shoe is not within the section.

It is not necessary for the three-conductor cable to extend over quite the entire length of the steel conductors. Figure 4 shows the steel extending out for a distance, a, beyond the end of the cable. This distance, a, should not be more than about ¼ of the distance, b, between taps. This will give a balanced design in which the voltage drop over the final length, a, will be approximately equal to the maximum drop which may occur within a section between taps.

RELATIVE POSITION OF STEEL AND COPPER

It was found that when single-conductor cables or bare copper wires are used, these paralleling copper conductors should not be placed too close to the steel rails or angles. If the steel and copper are within a few inches of each other, circulating currents may be induced which will result in relatively high voltage drop and electrical losses.

A recent experience illustrates this. A coal-handling bridge employed a collector system of the type shown in Figure 5. Table I shows the results of measurements taken on this system. It is seen that the voltage drop was about 20 per cent greater than that of the copper alone and nearly four times that of a three-conductor cable. Also the losses were about three times those of a cable of the copper conductor size used. The voltage drop was appreciably less than would occur if no copper were used, but the most effective use of the copper was not obtained.

To demonstrate that the high voltage drop and losses

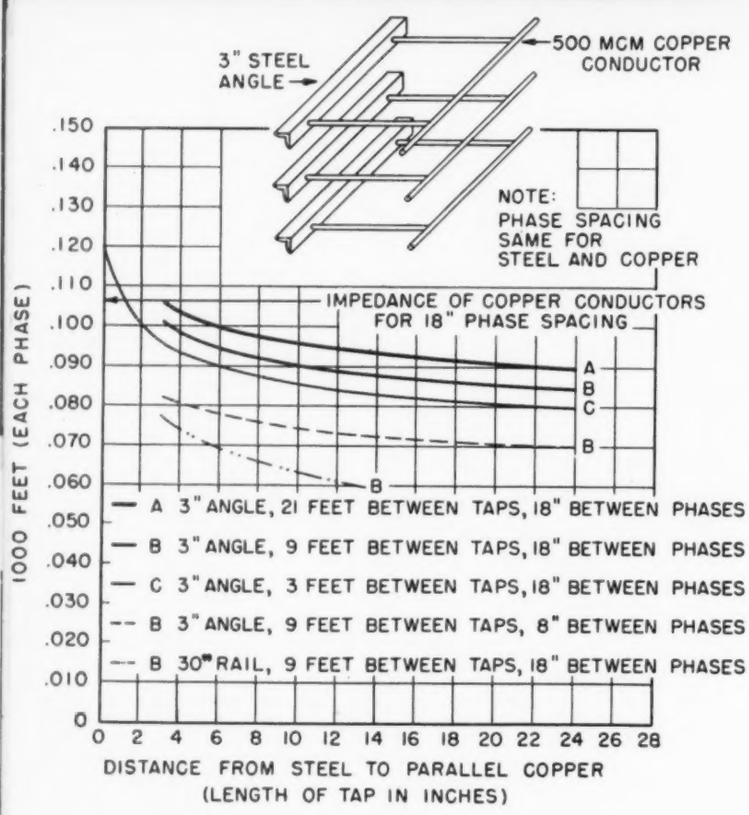


Figure 7 — Collector system impedance, showing effect of changes in distance between steel and parallel copper.

were influenced by the proximity of the steel and copper, laboratory tests were taken in which the distance between steel and copper was varied.

Figure 6 is a photograph of the laboratory set-up used and Figure 7 shows the results obtained. Figure 7 shows that the copper should be 15 inches or more from the steel to eliminate the effects of circulating currents. These effects are seen to cause the impedance of the system of Figure 5, with copper and steel adjacent, to be nearly 50 per cent greater than is the case where the copper and steel are separated by a distance of about 15 inches.

For the laboratory set-up described, the spacing between copper conductors was the same as between the steel conductors. If three-conductor cable is used, it is expected that a spacing between steel and copper somewhat less than 15 inches can be used without affecting the voltage drop.

DESIGN PROCEDURE

To design a collector system with good voltage regulation may require a trial-and-error procedure. In many cases, only one or two trials will be sufficient. It may, however, be necessary to estimate the voltage drop for several designs in order to select the best one. Use of information given in this paper should assist the designer to make the best design in the most direct manner. A suggested procedure is as follows, based on the type of construction shown in Figure 3.

1. Select an arrangement for power supply for the first trial design from the arrangements shown on Figure 2.
2. Select a type of steel conductor to be used.
3. Select a spacing of steel conductors.
4. Select a number and size of three-conductor cables for paralleling the steel conductors.
5. Select a number and location of taps.
6. Estimate the maximum voltage drop.
7. Repeat with a new design, if necessary.

For estimating the maximum voltage drop, the following procedure is suggested.

1. Estimate the maximum current and its power factor. The maximum current may be a peak load current, a motor starting current, or a combination of these.
2. Estimate the voltage drop in the power supply to the collector system.
3. Consider the collector shoe or wheel to be located in the middle of the last section between taps.
   (a) Estimate the voltage drop to the next to last tap using Figure 9.
   (b) Estimate the voltage drop in the last section using Figure 10.
   (c) Add the voltage drops from steps 3(a) and 3(b) to the drop to find the collector system drop.
4. Step 4 is not necessary if the last tap is at the extreme end of the system. When the last tap is not at the end of the system, consider the collector shoe or wheel to be located at the extreme end of the system.
   (a) Estimate the voltage drop to the last tap using Figure 9.

Figure 8 — Voltage drop in steel conductors for 440 volt, 3 phase, 60 cycle collector systems with 18 in. spacing of steel conductors.

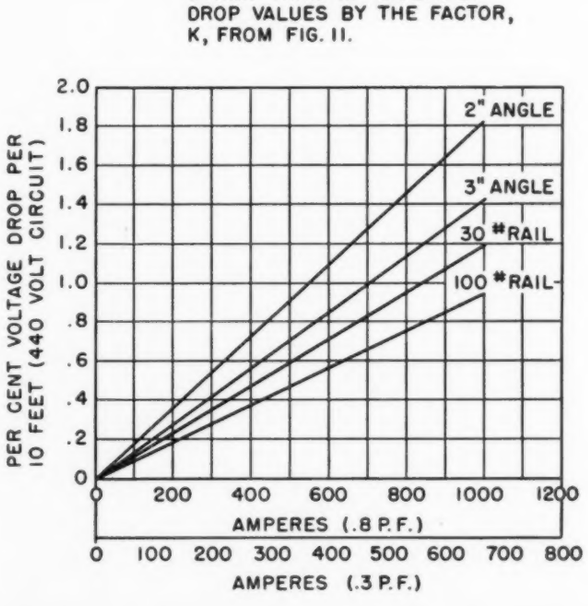


Figure 9 — Voltage drop between taps on 440 volt, 3 phase, 60 cycle collector system.

Figure 10 — Voltage drop in section from which load is taken, for 440 volt, 3 phase, 60 cycle collector system, with 50 ft tap spacing.

(b) Estimate the voltage drop in the final section of steel conductor using Figure 8.

(c) Add the two voltage drops from steps 4(a) and 4(b) to find the collector system drop.

5. To obtain the maximum total drop, add the drop in the power supply system to the larger of the drops obtained from steps 3(c) and 4(c). When there is more than one collector system, the maximum drop in each should be included, and also the drop in the cables between collector systems.

If the arrangement for power supply is of the type shown on Figure 2(c), additional calculations should be made to estimate the voltage drop occurring with the collector shoe or wheel at the midpoint of the system.

Although several steps are required to estimate the voltage drop for each case, the figures are intended to simplify most steps, so that each voltage drop estimate can be made quickly and easily.

The procedure for estimating voltage drop is illustrated by the following example.

EXAMPLE

Assume that an a-c coal bridge fits the following description. Figure 12 is an illustrative plan view sketch.

Length of bridge: 320 ft total
Each leg 60 ft from corresponding end of bridge.

Length of coal yard: 1000 ft.

Motors:

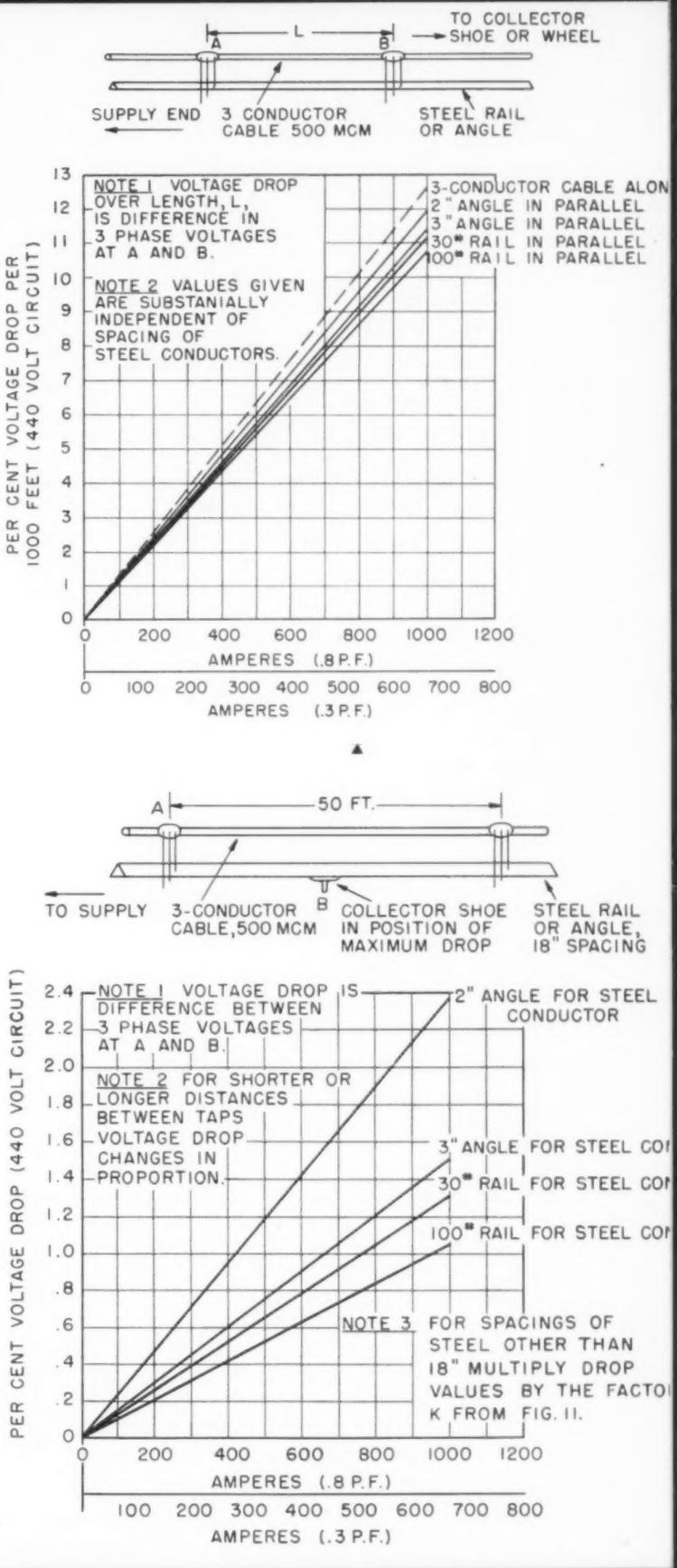
Hoist motion . . . . 2–75 hp wound rotor induction motors
Trolley motion. . . 2–50 hp wound rotor induction motors
Bridge motion . . . 4–30 hp wound rotor induction motors

Operating voltage: 440 volts, 3 phase, 60 cycles.

Power supply is through one 300 kva transformer bank connected to a large 6600 volt system and located 500 ft from each end of the coal yard.

Assume that a tentative design of collector system is as follows:

	Collector system along coal yard	Collector system along bridge
Power supply arrangement	Figure 2(b)	Figure 2(a)
Steel conductors	3–30 lb rails	3–3 in. angles
Steel conductor spacing	18 inches	18 inches
Copper conductors	1–3/C cable (500,000 cm)	1–3/C cable (500,000 cm)
Tap location	1 each 100 ft including 1 at each end.	1 each 50 ft to within 10 ft of each end.


TO COLLECTOR SHOE OR WHEEL
L
A
B
SUPPLY END
3 CONDUCTOR CABLE 500 MCM
STEEL RAIL OR ANGLE
NOTE 1 VOLTAGE DROP OVER LENGTH, L, IS DIFFERENCE IN 3 PHASE VOLTAGES AT A AND B.
NOTE 2 VALUES GIVEN ARE SUBSTANIALLY INDEPENDENT OF SPACING OF STEEL CONDUCTORS.
3-CONDUCTOR CABLE ALON
2" ANGLE IN PARALLEL
3" ANGLE IN PARALLEL
30" RAIL IN PARALLEL
100" RAIL IN PARALLEL
PER CENT VOLTAGE DROP PER 1000 FEET (440 VOLT CIRCUIT)
AMPERES (.8 P.F.)
AMPERES (.3 P.F.)
A
50 FT.
B
TO SUPPLY
3-CONDUCTOR CABLE, 500 MCM
COLLECTOR SHOE IN POSITION OF MAXIMUM DROP
STEEL RAIL OR ANGLE, 18" SPACING
NOTE 1 VOLTAGE DROP IS DIFFERENCE BETWEEN 3 PHASE VOLTAGES AT A AND B.
NOTE 2 FOR SHORTER OR LONGER DISTANCES BETWEEN TAPS VOLTAGE DROP CHANGES IN PROPORTION.
2" ANGLE FOR STEEL CONDUCTOR
3" ANGLE FOR STEEL CO
30" RAIL FOR STEEL CO
100" RAIL FOR STEEL CO
NOTE 3 FOR SPACINGS OF STEEL OTHER THAN 18" MULTIPLY DROP VALUES BY THE FACTO K FROM FIG. 11.
PER CENT VOLTAGE DROP (440 VOLT CIRCUIT)
AMPERES (.8 P.F.)
AMPERES (.3 P.F.)

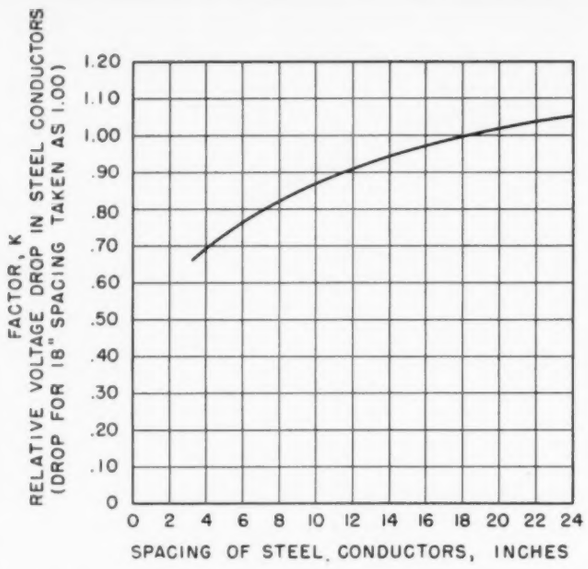


Figure 11 — Effect of spacing of steel conductors on voltage drop in steel conductors for 3 phase, 60 cycle collector systems.

50 foot tap spacing. For the 100 foot tap spacing used, the voltage drop is .9 per cent.

3(c) From 3(a) and 3(b) for the yard collector system the total drop in this system is 2.5 per cent. (.9+1.6 =2.5) Since the last tap is at the extreme end of the system step 4 is not required.

Collector system on bridge

3(a) Consider the collector shoe to be located in the middle of the last section between taps. The distance to the next to last tap (from the bridge leg at which the power supply cable is connected) is 200 feet. From Figure 9, for 360 amperes at .8 power factor and 3 in. angles the voltage drop per 1000 feet is 4 per cent. For 200 feet the drop is .8 per cent. (.200 x 4% = .8%)

3(b) From Figure 10 for 360 amperes at .8 power factor and 3 in. angles, the voltage drop in the last section (with the shoe in the middle) is approximately .5 per cent.

3(c) From 3(a) and 3(b) for the bridge collector system, the voltage drop in this system, for collector shoe located at the middle of the last section between taps is 1.3 per cent. (.8+.5=1.3)

The maximum voltage drop may be estimated as follows, in accordance with the outline given under "Design Procedure."

1. Assume that the maximum current flows when the two hoist motors are accelerating, with the controller adjusted to limit the current to 200 per cent, and with other motors not operating. Thus the maximum current will be about 360 amperes at approximately .8 power factor.
2. Estimate voltage drop in power supply system to be 3.5 per cent. This neglects the drop in the 6600 volt system. The drop through the transformer is estimated as follows:

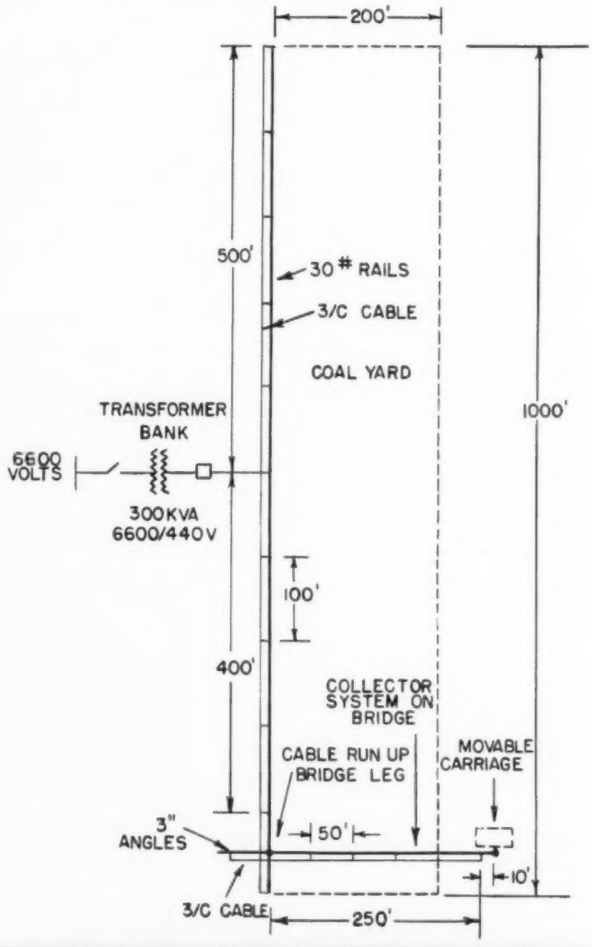
   The current, 360 amperes, corresponds to 274 kva, 3 phase, at 440 volts. This is 92 per cent of the transformer rating, 300 kva. Assuming transformer reactance and resistance to be 5 per cent and 1 per cent respectively, the drop may be calculated to be approximately 3.5 per cent. (.92 x .8 x 1%+.92 x .6 x 5%=3.5%). This calculation considers the power factor to be 80 per cent, which means a reactive kva of 60 per cent of the total kva. ($.80^2+.60^2=1.00$)
3. It is necessary to consider the drop in the collector system along the coal yard, and also that on the bridge. The drop in the cable run up the bridge leg will be neglected in this example.

Collector system along coal yard

3(a) Consider the bridge to be located near one end of the yard with the collector shoe in the middle of the last section between taps. The distance to the next to last tap is 400 ft. Using Figure 9, for 360 amperes at .8 power factor and 30 lb rails, the voltage drop per 1000 feet is 4 per cent. Thus for 450 feet the drop to the last tap is 1.8 per cent. (.400 x 4%=1.6%)

3(b) From Figure 10 for 360 amperes at .8 power factor and 30 lb rails the voltage drop in the last section (with the shoe in the middle) is .45 per cent for a

Figure 12 — Collector system for coal bridge.



4(a) Consider the collector shoe to be located at the extreme end of the bridge. The distance to the last tap (from the bridge leg at which the power supply cable is connected) is 250 feet. From Figure 9, for 360 amperes at .8 power factor and 3 in. angles, the voltage drop per 1000 feet is 4 per cent. For 250 feet the drop is 1 per cent (.250 x 4% = 1%)

4(b) From Figure 8, for 360 amperes at .8 power factor and 3 in. angles the voltage drop for 10 feet is .5 per cent.

4(c) From 4(a) and 4(b) the voltage drop in the bridge collector system, for collector shoe location at the extreme end of the system, is 1.5 per cent (1.0+.5 =1 5). Note that this is larger than the value obtained from step 3(c).

The total drop is obtained by adding the individual drops previously calculated.

	Step	Voltage drop, per cent
Power supply (transformers)	2	3.5
Yard collector system	3(c)	2.5
Bridge collector system	4(c)	1.5
Total		7.5

This total drop is the change in voltage from no load to peak load. With the transformer taps adjusted to give a no load voltage slightly above motor rated voltage, the drop below rated voltage will be somewhat less than 7.5 per cent.

DISCUSSION

PRESENTED BY

JAMES FARRINGTON, Superintendent, Electrical Department, Wheeling Steel Corporation, Steubenville, Ohio

W. K. BOICE, Industrial Engineering Department, General Electric Company, Schenectady, New York

C. E. HAMILTON, JR., Electrical Engineer, Heyl and Patterson Company, Pittsburgh, Pennsylvania

J. D. O'ROARK, Electrical Foreman, Weirton Steel Company, Weirton, West Virginia

L. N. GRIER, Aluminum Company of America, Pittsburgh, Pennsylvania

JAMES FARRINGTON: I would like to ask what is the highest voltage used on a-c collector circuit? We have a proposition for an ore bridge on which we propose using 2200 volts, carrying the lines up one leg of the bridge to the foot walk and using a 3-phase transformer, 2200 to 440 volt. On inquiring around I have been unable to learn where such a system was installed on an ore bridge recently, but about 15 years ago a coal bridge was equipped with collector rails for 11,000 volts. I thought we were pioneering, but find somebody else went to five times as much voltage fifteen years ago and it is still in service.

On one of our coal unloader collector systems about 1100 feet long, we have 440 volts and use three rails. We have three single conductor cables on the outside of the single conductor arm and take taps off from that every so often. That has been in operation about twenty-two years and has given absolutely no trouble. Automatic control is used from a d-c armature direct connected to a 375 hp main hoist motor without any exciter. The lowering speed is 10 per cent faster than the hoisting speed. Control and motors have given us excellent results. I want to inquire if there have been any ore bridges built lately that had 2200 volt collector systems.

W. K. BOICE: I would not feel justified in saying whether there have been any built or not. In recent times we have considered controls for 2200 and 6600 volts. There is no fundamental reason why 6600, or even higher, could not be used provided precautions are taken in the rail system in collector shoes for adequate allowance for creepage. I think they should be considered in long bridges. If you want to transmit 1000 feet or more at 440 volts it is a problem to get enough copper to carry that circuit that distance. In long runs the voltage drop should be taken into consideration even for 2200 volts and higher.

C. E. HAMILTON, JR.: Mr. Farrington asked about high a-c voltages on ore bridges. In the northwest we have 13,200 volts on some built in 1912. After the first installation we had no difficulty on that voltage. We have quoted on 2300 volt collector systems for one of the public utility companies in New York. We have quoted on 2300 volt collector systems for Ohio Edison Power Company. Within the last two years we quoted on equipment for the Chicago Edison Company on which the contract was for 2300 volts. We have a number of 440 volt systems around the country, on which we haven't heard anything bad.

J. D. O'ROARK: I wonder in the adaptation of these higher voltages, if you would get into higher rotor voltages and high peak currents in rotor windings of the hoist motors, making it difficult for the manufacturer to build a motor to withstand the severe duty imposed.

W. K. BOICE: In answer to Mr. O'Roarks' question about motors for operating voltages higher than 440 volts, I would not anticipate any troubles due directly to use of a higher voltage. Often the design of the rotor of a higher voltage motor is exactly the same as for similar 440 volt motors.

I am pleased to observe the interest shown in the information given in the paper. Recognition of the desirability of designing for minimum voltage drops in a-c collector systems and an understanding of the factors which contribute to such drop should be very helpful in obtaining best performance from a-c crane equipment.

L. N. GRIER: What was the ratio of resistance drop to reactance drop in the crane conductors? If the principal drop is resistance, this can be materially reduced by the use of aluminum shapes instead of steel angles.

W. K. BOICE: I would be interested in hearing more about that. I do not know what the wear would be on that aluminum.

L. N. GRIER: Our experience indicates satisfactory results if a good grade bronze collector shoe is used.

SUPERIMPOSED *Precipitators* FOR THE *Cleaning* OF BLAST FURNACE *Gas*

. . . . the use of an electric precipitator located on top of a primary gas washer conserves ground space and simplifies gas-main and sewer layout . . . .

by B. B. Frost

ARTHUR G. McKEE COMPANY

CLEVELAND, OHIO

▲ THE problem of fine cleaning blast furnace gas, like most other industrial problems, has no single answer which applies to all cases. There are many uses for the gas outside the blast furnace area, each requiring a different degree of cleaning and each placing a different value on the gas as a fuel. The internal economy of each plant dictates the degree of cleaning and to a certain extent the method to be used. There are then many combinations of cleaning units capable of producing the desired cleanliness in the outlet gas. A balance must therefore be made between service requirements, pressure loss, original cost and many other interrelated items.

The degree of cleaning required for various plant uses of blast-furnace gas depends upon local conditions and the application of the gas. If the cleaning of gas for coke ovens and metallurgical purposes is eliminated from this consideration, the principal uses are in stoves and boilers. The modern high-efficiency stove should not be subjected to continued firing with gas containing more than 0.025 grains of dust per cu ft. Gas cleaner than this can be justified in many cases, for as the dust content is allowed to rise, the life of the top checker brick is materially reduced by the fluxing action of the dirt on the checkers.

The gas for firing boilers can be considerably dirtier than that used on stoves if the steam-generating units are properly baffled and arranged for a wide tube spacing. In such boilers primary washed gas ranging from 0.15 to 0.30 grains per cu ft gives reasonably satisfactory results, although the burners and boiler tubes must be cleaned at frequent intervals. In some places, raw gas delivered from a secondary dust catcher or centrifugal cleaner, containing one to two grains of dust, is fired in combination with pulverized fuel, and the slag formed by the dust merges with the fused ash in coal and is disposed of by the ash-handling equipment. Where, however, the surplus blast-furnace gas forms a large part of the boiler fuel, it is economical to clean all blast-furnace gas to the same cleanliness as is required for high-efficiency stoves. This simplifies the gas system and reduces interruptions in boiler operation to a minimum.

The first unit to be considered in setting up the equipment for a fine cleaning plant is the primary gas washer. Many attempts have been made to solve the problem of satisfactory wet washing in a single tower scrubber without excessive use of power. Many units have been highly successful at one plant but duplicate installations operating under different furnace conditions have produced decidedly poorer results. The original static tower washers designed to operate at low pressure differentials have in many instances given reasonably good results without excessive consumption of water. However, this type of primary gas washer serves principally as a gas cooler, in which contact between gas and water is brought about by the combined action of water sprays and hurdles through which pass the gas and sprayed water particles.

Gas and water contact depends primarily upon the impingement of gas against the wetted surfaces of the

Presented before A. I. S. E. Cleveland-Youngstown District Sec. Meeting, April 19-20, '43

TABLE I

Gas volume, cfm	235,000		210,000	
Number of units in operation	3	2	3	2
Inlet dust loading, grains per cu ft	.25	.25	.15	.15
Effiiciency, per cent	95	85	96–97	87–90
Outlet dust loading, grains per cu ft	.0125	.0375	.006–.008	.02–.025

hurdles, which are likely to plug unless gas and water distribution through the unit can be perfectly maintained. The introduction of one or two low-head recirculating pump units in the form of rotors in the bottom of the tower washer, to create a more intimate contact between gas and water before the gas reaches the hurdles or tile baffles, has in such installations virtually removed the difficulties from plugging of both hurdles and the washer bottoms. In many instances these rotor elements have made it possible to reduce the water consumption from 30 gal to about 20 gal per 1000 cu ft of gas.

Washers of this nature can be counted on to clean the gas to some figure between .25 and .15 grains per cu ft. They operate on a low differential pressure and require less power input than washers which carry the cleanliness down to figures between .05 and .1 grains per cu ft. Cleaners giving these higher efficiencies include those using perforated impingement plates, mist producing rotors, high pressure sprays in venturi throats impinging on a bubble cap and high pressure mist sprays. These washers all have high power requirements either due to pumping water at high pressures or from the resistance to the flow of gas in the unit which will be reflected in the blowing costs.

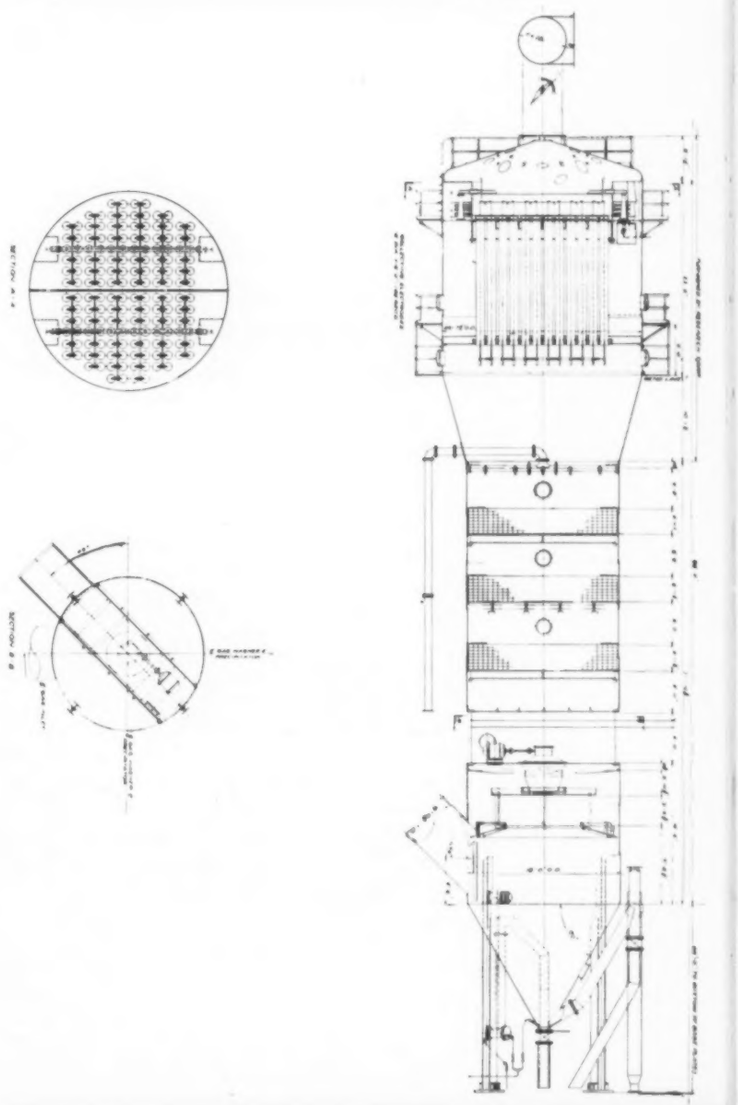
These units can be counted on to give outlet gas cleanliness of 0.1 grains or less, but for the purposes of this discussion where consistently better cleaning is to be covered they are not considered applicable and will therefore not be discussed further.

The secondary or fine gas cleaning unit may be either a precipitator or disintegrator. The choice between disintegrators and precipitators for fine cleaning of blast-furnace gas must in general be made on the basis of two main factors, the cost of capital and the cost of power. This statement is based on the fact that a disintegrator installation is generally considerably cheaper than a precipitator for the same work, but the power requirements are very much greater. There are, however, many other factors to be considered in choosing between these two types of equipment, each of which has very definite advantages and disadvantages. Aside from the lower initial costs, the disintegrator has the advantage of being capable of boosting, of flexibility in the matter of regulation of cleaning efficiency, of simple and easily maintained adjustments and of consistent performance under wide fluctuations of inlet loading.

Offsetting these advantages are the disadvantages of higher operating costs, greater water consumption, higher maintenance costs and the possible dangers of producing a negative pressure in the gas system in case of a sudden loss of gas pressure at the disintegrator inlet. The precipitator, on the other hand, has the advantage of lower operating costs, minimum of moving parts and very low gas-friction losses. However, its adjustments are somewhat difficult to maintain under some conditions, its efficiency is not constant under severe conditions of inlet loading, its flushing water must be relatively clean and the cost of protecting its wetted surfaces is high if corrosive water is to be used.

Space requirements in many plants have been, and

Figure 1 — Cross section of washer and precipitator.



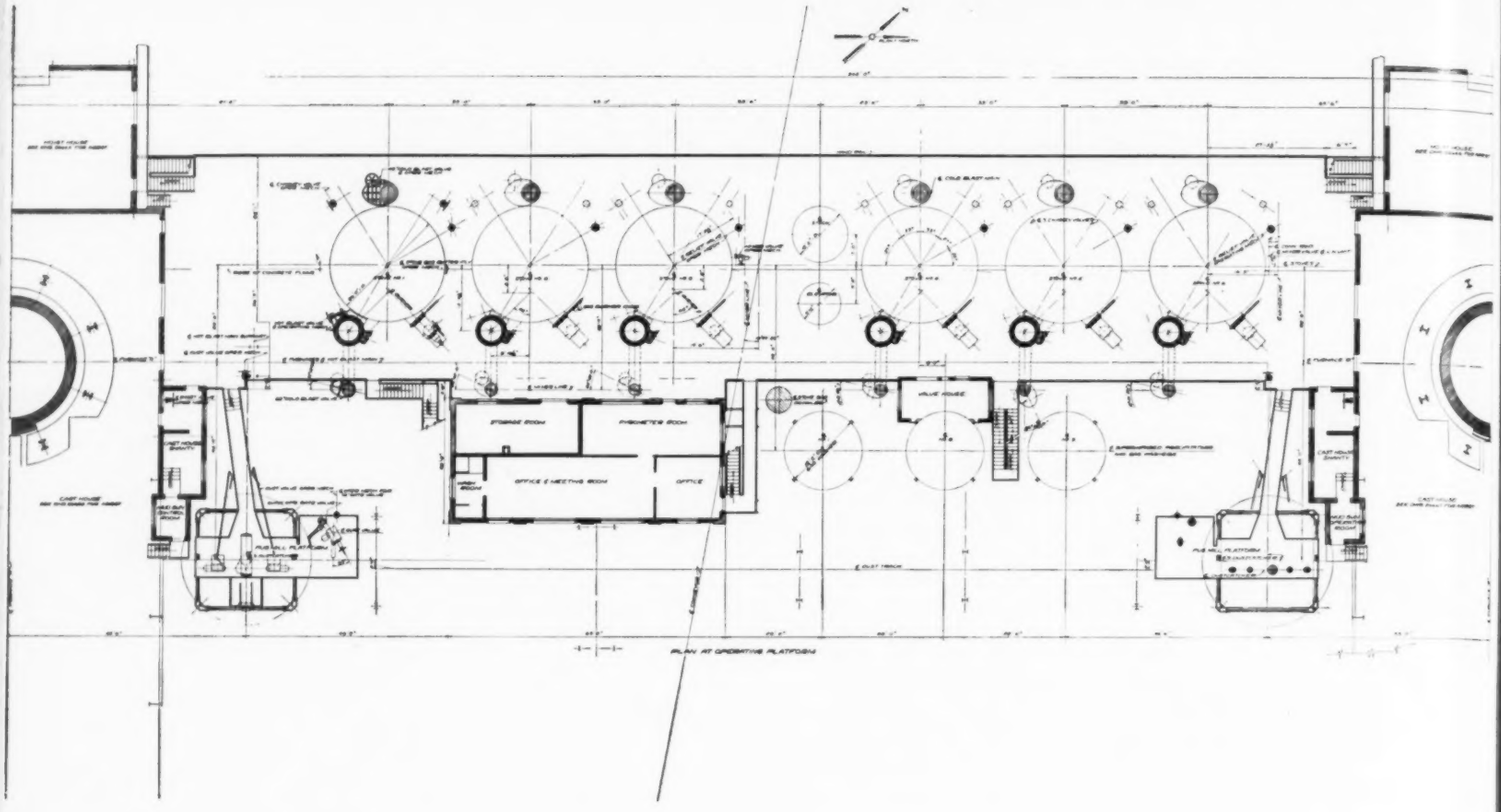


Figure 2 — Plan of plant at stove operating platform level.

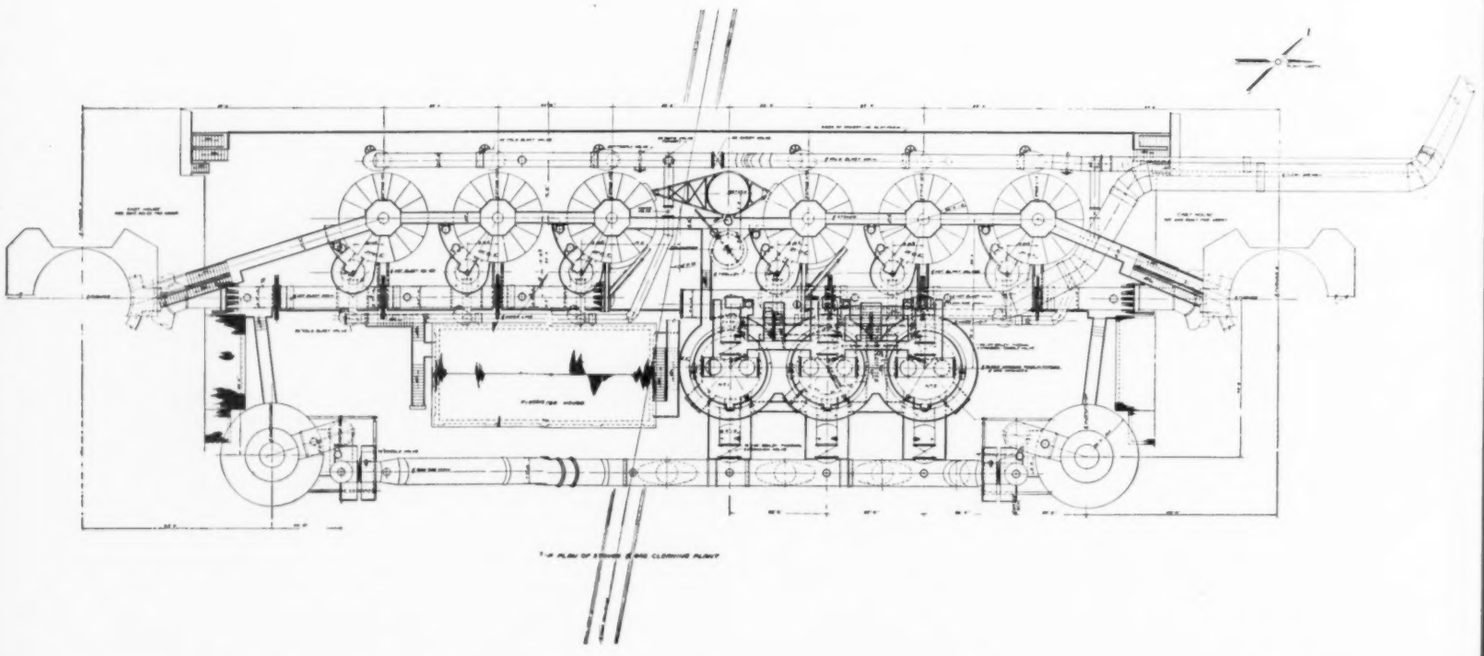


Figure 3 — Plan of plant.

will continue to be, more of a factor as furnaces and auxiliary equipments are enlarged on existing sites. In order to conserve ground space precipitators have been, and are being, superimposed on primary gas washers with excellent results. This type of installation is not a great deal cheaper, if any, than one in which the precipitator is on the ground, but has the marked advantage of reducing the ground space required and simplifying the gas-main and sewer layouts. The number of valves is reduced and the operating hazards are diminished.

It is unfortunate that the gas cleaning plant to be described is not in operation, therefore no actual operating figures are available. I wish to point out, however, that the use of superimposed precipitators is not new. Two units have been giving excellent results in a plant in the Buffalo district for the past four and one-half years and are, at present, being augmented by a third unit which will be placed in an existing stove shell. The units to be discussed here are, however, the first to be incorporated in a new plant where they could be fitted into the design to their best advantage. They are now being built in a plant in the Chicago district, and are composed of three superimposed precipitator washer units with the ratings and expected performance shown in Table I.

The plant is designed to give ample cleaning capacity at the maximum gas production of the two furnaces. If one unit is out of service, the two remaining units will be capable of a creditable performance under maximum flow conditions while at any lower rates of blowing the cleanling efficiency will be proportionally better.

The washer units themselves (Figure 1) are 18 feet in diameter, 52 feet high, consisting of one rotor element immediately above the gas inlet followed by three 3 ft banks of drip tile. The spray header is at a suitable distance above the upper tile bank and is made up of twenty-six 2½ in. nozzles which will deliver water at the rate of 2340 gpm with 10 psi pressure in the header.

Many washer units of this general design are in operation and it is safe to assume that under normal furnace conditions, when producing basic iron, a dust content of .25 grains per cu ft or less can be regularly depended on. These washers have of course been able to produce outlet cleanliness considerably better than 0.25 grains per cu ft under particular operating conditions, but in considering this particular case it was thought best to provide precipitator capacity based on a maximum inlet loading of .25 grains per cu ft and a normal loading of 0.15 grains per cu ft.

For this purpose each precipitator unit is provided with 168 12 in. diameter tubes, 15 feet long. When using the three units the cleaning efficiency should be 95 per cent, giving an outlet loading of .0125 grains per cu ft under the worst conditions of inlet loading and gas flow. This gas is ideally suited for fine checker stoves and high efficiency boilers for which it is to be used. If it is found necessary to operate on only two units during periods of maximum gas flow, the efficiency of cleaning will be reduced to about 85 per cent and the outlet loading will be increased to .038 grains per cu ft. While this dust concentration would eventually prove detrimental to both stoves and boilers, particularly the boiler burners, short periods of such operation should not prove to be serious.

During periods of normal operation, with a rate of blowing of 70,000 to 75,000 cfm on each furnace and an inlet loading of .15 grains per cu ft, the precipitator efficiency will be 96 per cent with .006 grains per cu ft in the outlet gas; and when only two units are to be used an efficiency of 88 per cent will be had with an outlet loading of only .018 grains per cu ft. Gas under either of these conditions is entirely suitable for the stoves and boilers and could be quite safely used as an underfiring fuel for the coke plant.

The foregoing summary of operating conditions illustrates the flexibility of the three unit system used on two furnaces. It gives the operator the chance to frequently inspect washer units and thus maintain gas cleaning efficiency without affecting the output of the furnaces.

The physical layout of the plant, (Figures 2, 3, 4 and 5) presents some interesting points regarding the raw gas main design and the actual arrangement of the cleaning units. The gas cleaning plant shares the space between the two dust catchers with the pyrometer house and pump house. This places the washers near the stove platform, and accessible from it at that level and from the stoves at the top level. This location results in short raw and clean gas mains and still allows ample room at the furnaces and stoves.

The raw gas header connecting the two water seals serves to feed the gas washing plant. It is 6 ft 9 in. in diameter inside the 4½ in. brick lining and, where flat, (100 ft adjacent to the washers) is provided with three large dust legs discharging above the dust track which is common to the two furnaces. The remainder of the raw gas main is inclined at 25 degrees to the horizontal so that flue dust will not accumulate, but will be carried to the dust legs (Figure 6).

Each washer is fed from the raw gas header through 72 in. thermal expansion valves. The washer inlet connections are short and unlined, but are provided with 5/16 in. high carbon liners on the elbows. The actual inlet is inclined at 45 degrees while the washer cone is at 60 degrees to the horizontal. This relation of inlet and cone angle tends to prevent dust building up below and in the washer inlet.

The bottom section of the washer (Figure 1) below the rotor and its feed pan and above the inlet is made up of a circular tray serving as a weir on both sides. The outer lip of this baffle does not touch the washer shell except for 60 degrees over the inlet which is welded to prevent any water leakage into the inlet connection. The open space of 3 in. around the remaining 300 degrees of circumference allows the water to flow down the washer shell and cone preventing an accumulation of flue dust. The remainder of the water passes over the inner circumference of the baffle presenting a sheet of water through which the gas must pass. This gas impinges on the bottom of the rotor pan, passing around the pan, through the sheets of water thrown out by the rotor and then around the shelf baffle and the rotor tunnel.

The rotor itself operates at about 140 rpm and serves as a low head high volume pump. The water is picked up in the lower pan, passing upward through the concentric cones of the rotor where it is thrown off forming a series of horizontal sheets of water which pass over

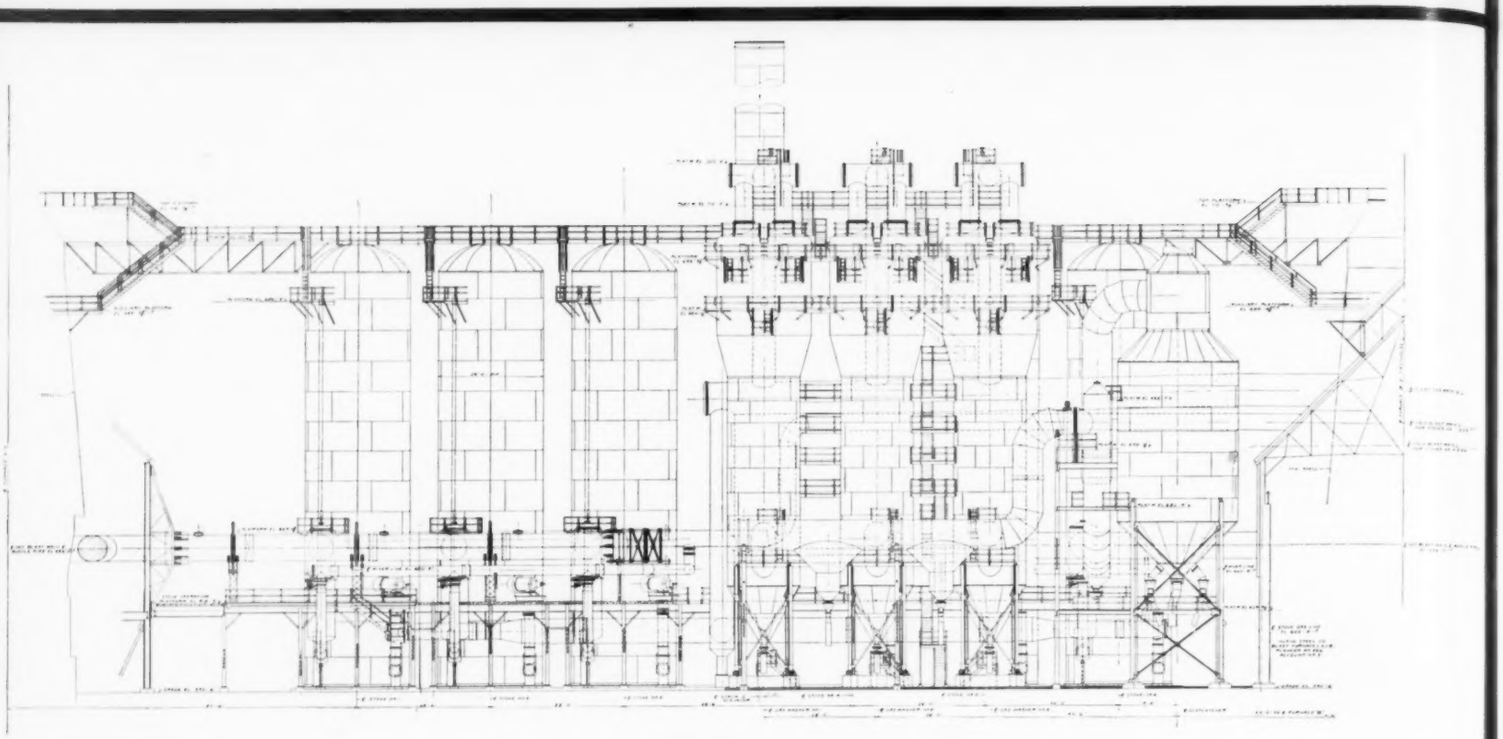


Figure 4 — Elevation of stoves and gas washing plant.

the shelf baffle and impinge against the washer shell. This water drains back into the rotor pan where it is repumped by the rotor. The circulation of water in this system is about 3000 gpm regardless of the volume of water being fed at the spray header. The overflow from the rotor pan to the bottom baffle and thence to the cone is of course equal to the volume of water fed into the top of the washer.

The bottom section described, while not entirely freeing the lower part of the washer from an occasional accumulation of flue dust, is believed to provide a satisfactory solution of the worst feature of tower washers, i.e. plugging in the inlet and bottom cone.

After the gas passes the tunnel section of the washer it travels up through the banks of drip tile where the greater part of the gas washing is accomplished.

The gas is then introduced into the precipitator section of the washer where it passes up through the tubes, and final cleaning is accomplished by the action of the electrostatic field set up between the grounded tube walls and the negatively charged discharge electrode hanging in the center of each tube. The voltage across the 6 in. air gap can be varied, but is usually maintained at about 75,000 volts. The corona discharge serves to ionize, or charge, the dust particles which are then attracted to the positive pole which is the inner surface of the wetted tube.

The precipitator tubes are supported by a header plate across the upper part of the precipitator shell, and are steadied by a grid frame work near the bottom of the tubes. This frame is equipped with adjusting bolts which are used to plumb the tubes.

Each tube is provided with a flared weir ring supported on a 1 in. sponge rubber gasket and held to the header plate by four cap screws. The pan formed by the header plate is divided into six ponds by division plates and each pond has its own water feed box and distributing system. The weirs on each tube are adjusted to provide an even water film on the surface of each tube. The discharge electrodes are hung from a high tension frame which is supported by post insulators located in separate housings inside the precipitator shell. The insulator compartments are heated with steam coils to prevent the precipitation of moisture on the insulators. One post insulator on each high tension frame is provided with an exterior bushing for connection to the high tension bus in the substation.

During normal operation a continuous flow of about 1½ gallons of water per minute is used to wet each tube. Periodically the overflow to the tubes is increased to its maximum and sprays which flush the high tension frame turned on. A maximum of 6.5 gpm per tube is used at this time. Under ordinary conditions, flushing periods are from five to ten minutes three times per day. Because this increased quantity of water causes considerable arcing, it is desirable, in most cases, to reduce the electrode voltage during these periods in order that serious arcing be averted.

Periodic inspection should be a part of the regular maintenance routine of precipitator installations, as any building up on the tubes is easily removed in its early stages, but if allowed to continue until serious operating trouble develops, a major job of cleaning and repair may be brought about. As previously stated the use of three units of suitable capacity gives the opportunity for these periodic inspections without a furnace shut down and its resultant reduction in production.

Butterfly valves are provided in the two outlet connections of each unit and are used to effect a balance between the units. A thermal valve separates each precipitator unit from the 8 ft clean gas header so that the units can be easily isolated.

WATER SYSTEM

The water to the washers and precipitators must be boosted above plant pressure and pumps for this purpose are located in the basement of the pyrometer house.

The gas washers are arranged for a normal water flow of 2000 gpm; therefore two 6000 gpm pumps are installed with one as a standby. In case two washers are operating the volume of water used on each washer may be increased to about 2600 gpm if the added water is needed.

The gas washer pumps discharge into a common 18 in. header which carries the water to a valve house at No. 2 washer. At this point the line branches into three 10 in. risers which lead to each washer spray header with suitable valving and flow meters.

The water requirement of the precipitators is complicated by the greatly increased flow required during the short flushing periods. It is assumed that 1½ gpm per tube will be used during regular operation and that a maximum of 6½ gpm per tube will be required when flushing. These flushing water requirements can be further broken down into that required for sprays and that coming from the overflow boxes. It is also assumed that only one-half of each unit will be flushed at any one time. Under these conditions, it is seen that the normal water requirements will be 750 gpm and flushing requirements 1176 gpm. For this service two 750 gpm pumps have been furnished. It is clear that one pump should be used continuously and the second started only during flushing periods which will take 30 minutes.

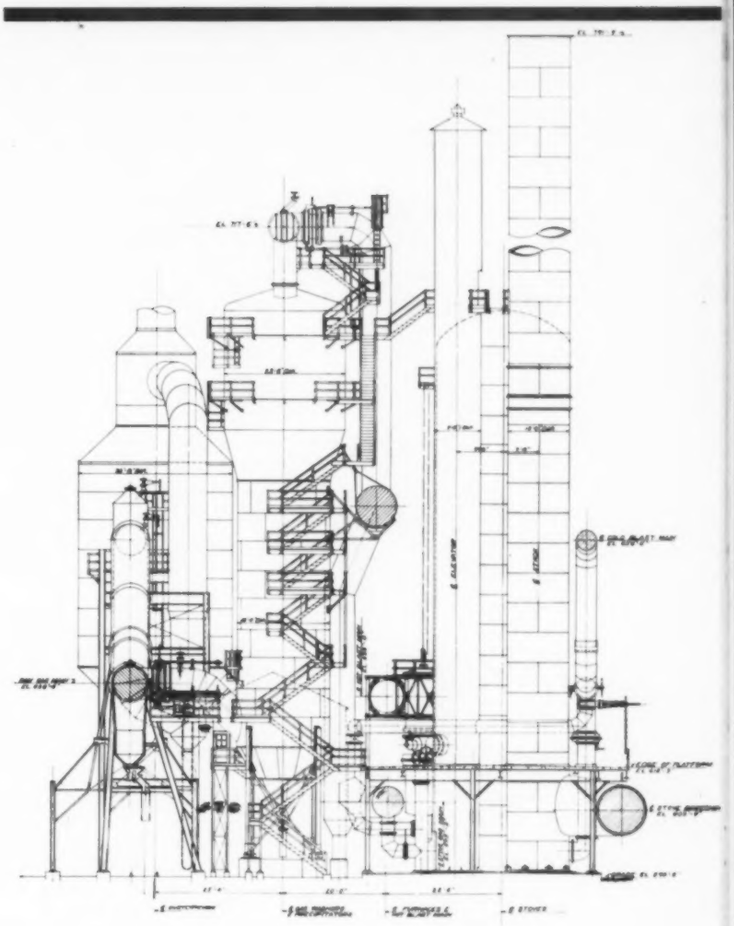
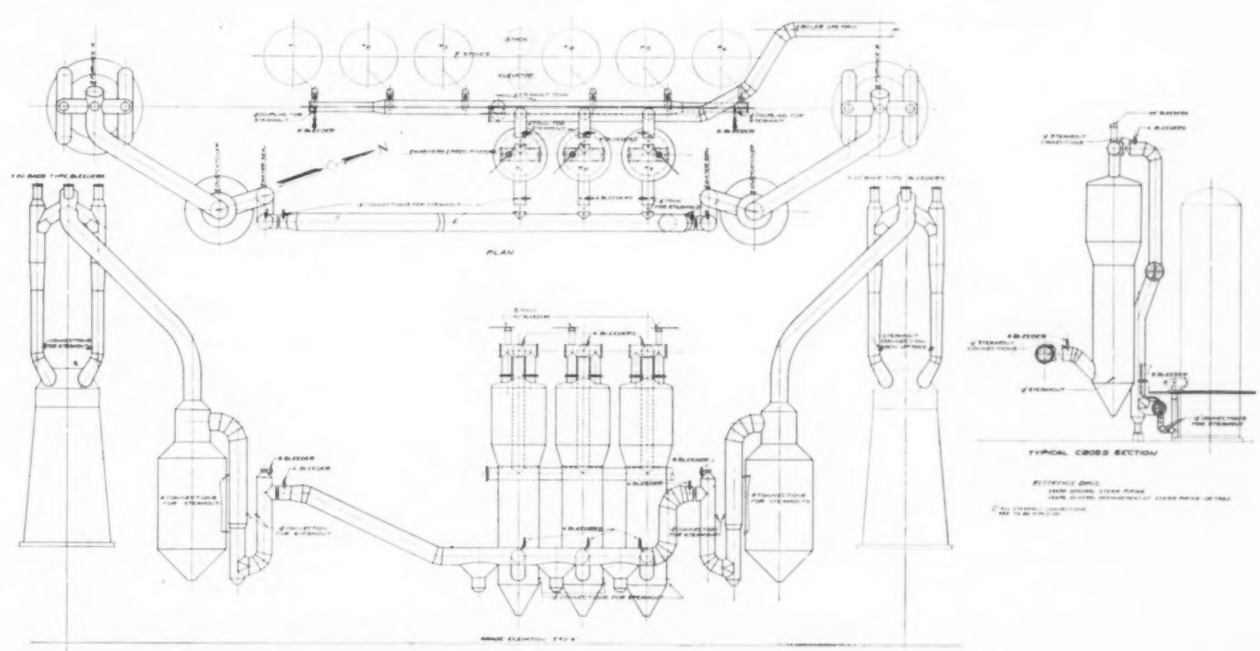


Figure 5 — Elevation of stoves and gas washing plant.

▲

Figure 6 — Arrangement of gas piping.



It is presumed that the pumps will be used alternately to relieve one unit of excessive starting service.

It is obvious that no provision has been made for a spare pump to be used for flushing during pump repairs. This contingency can be easily taken care of by reducing the normal overflow on all units during flushing periods to ¾ gpm per tube, which is considered a safe overflow volume. At the same time divide the flushing sequence into two operations; that is, use the sprays for five minutes and flush the distribution boxes for five minutes. Under these conditions the maximum flow rate will be 650 gpm which is well under the rating of one pump.

If this low flow of ¾ gpm per tube is an allowable operating condition, some people may question the advisability of predicating normal operation on twice this amount. This high flow rate is arrived at as follows:

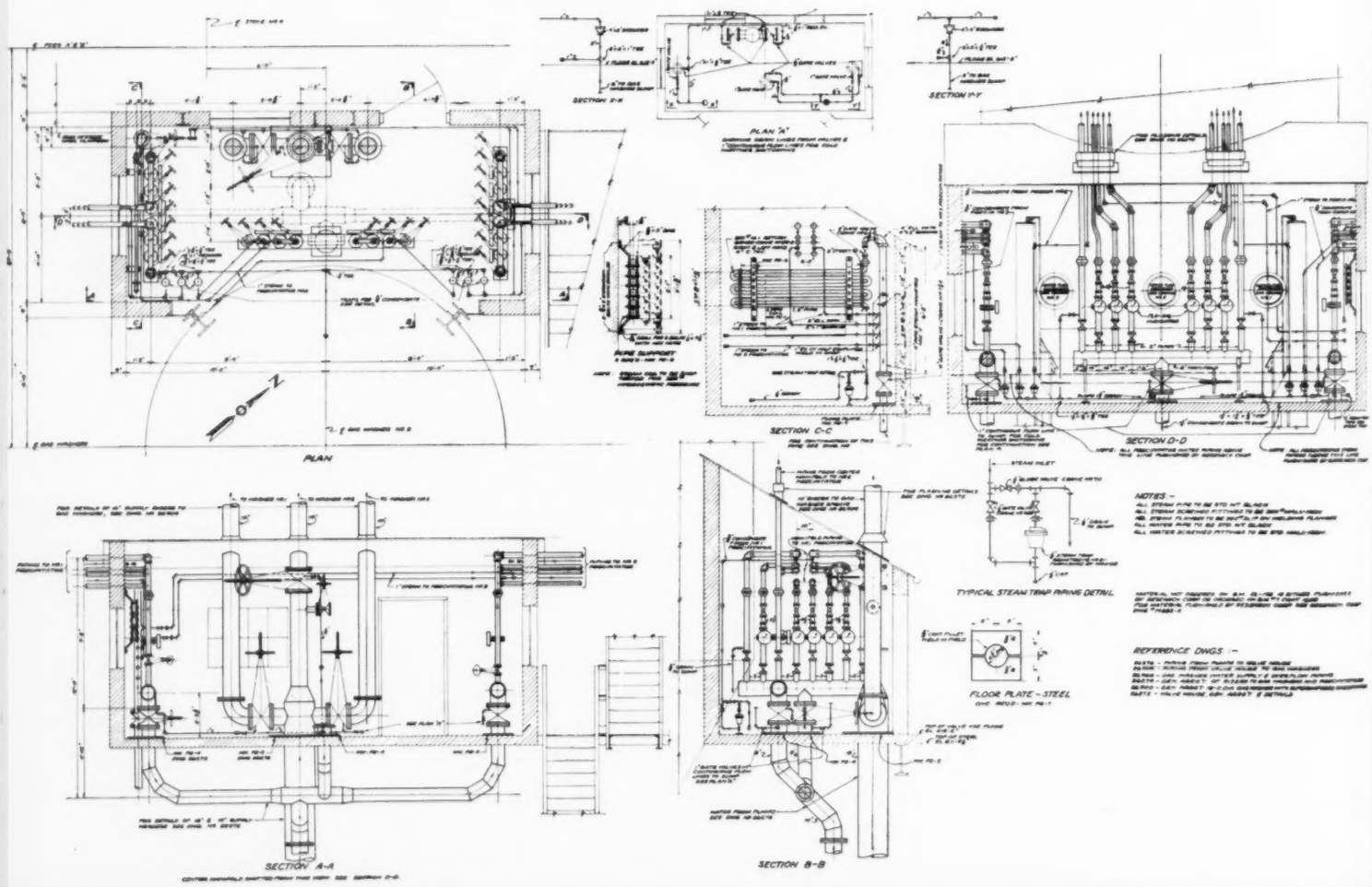
1. The water entering the superimposed precipitators is not lost as in the conventional system, as the precipitator overflow goes directly into the tower washer and is fully as useful in that form as though introduced through the sprays.

2. The greater the volume of overflow water used during normal operation, consistent with satisfactory electrical performance, the less tube cleaning and maintenance required.

With these facts in mind, the normal overflow requirements of each precipitator were set at what is believed to be an ideal rate, and the size of the gas washer pumps reduced. The present size, of 6000 gpm, for a maximum rate of gas flow of 213,000 cfm would not be considered adequate if it were not for the fact that 250 gpm are being introduced into each washer from the precipitator. Under these circumstances we have 2250 gpm available for each washer, which is slightly over 30 gal per 1000 cu ft of gas, and are furnishing water to the precipitator at the optimum rate.

Water leaves the precipitator pumps in a 10 in. header going to the valve house at No. 2 washer where it branches into three 8 in. risers feeding the three precipitator headers. Each header feeds six 3 in. risers to the distribution boxes for the precipitator. Each of these risers has a gate valve and a "Flo-Sig" indicator followed by a 2½ in. plug cock used for throttling. The "Flo-Sig" is made up of an eccentric butterfly working against a coiled spring. As the flow increases the angular position of the butterfly changes. The butterfly shaft is provided with a pointer and graduated scale. These

Figure 7 — Details of precipitator and washer piping in valve house.



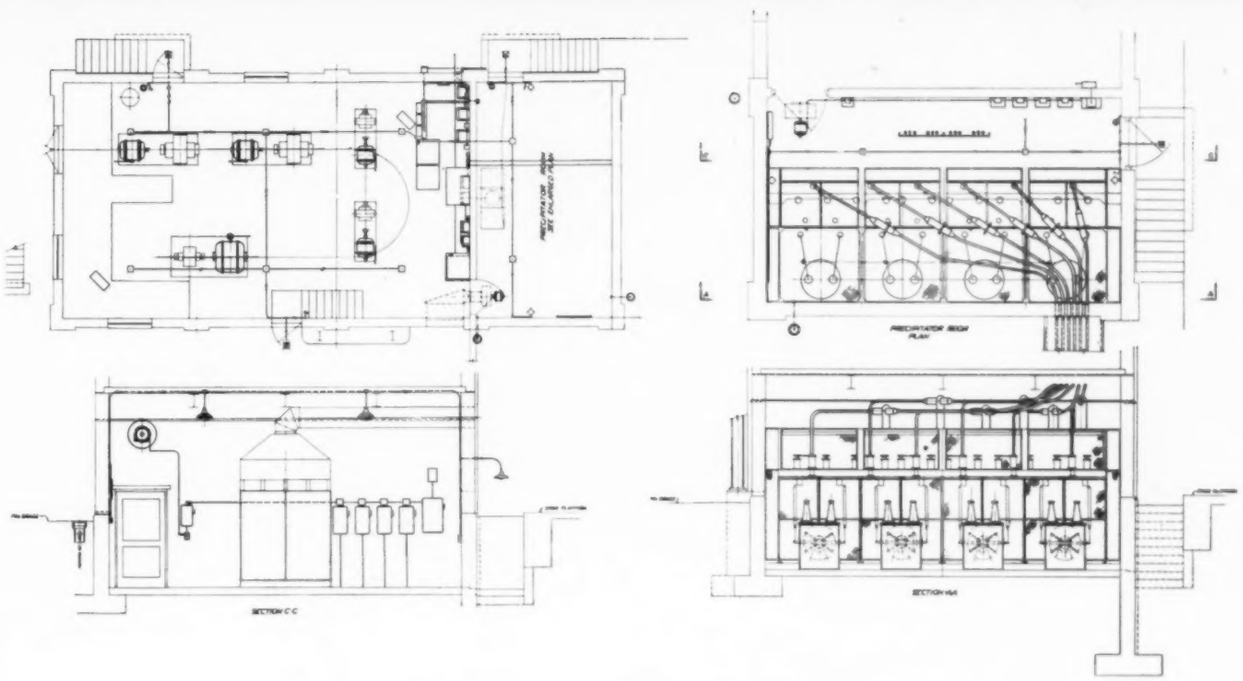


Figure 8 — Pump room and precipitator substation.

indicators are used to set the water flow to each distribution box and are calibrated for flow volume when placed in service. There are also two other 3 in. risers, not having "Flo-Sigs," leading to the precipitator spray piping. Figure 7 shows the arrangement of piping valves and flow meters in the valve house. This arrangement provides ideal conditions for control of the water to the gas cleaning plant from a centralized position.

The steam for the insulator compartments is also controlled from the valve house and the steam feeds and returns to the traps provide heating in the house and are used to trace the bundled water lines to afford protection from freezing. Since all valves for both washers and precipitators are in this heated house, no manure boxes or other protection from the weather are required to prevent freezing. Since the house is at the stove operating platform level it is possible for the furnace foreman to easily check up on the operators responsible for flushing the precipitator units and see that this operation is taken care of regularly and correctly.

All washer and precipitator lines are provided with drain connections on the washer side of the valve so that the lines can be protected when the washers are shut down.

ELECTRICAL SYSTEMS

The electrical equipment for the precipitator consists of four transformers, four control boards, rectifiers and high tension switching. Surge protection and voltage control are provided by variable primary resistance. This allows hand setting of the primary terminal voltage and therefore reasonably accurate control of the high voltage. The transformers are also arranged for tap changing at the board for changing transformer ratios.

Rectification is taken care of through a synchronous rotary convertor for each transformer which not only produces direct current, but is also arranged to give half wave rectification. One-half wave is sent to each half of each precipitator unit. This pulsating high voltage impulse aids in breaking up power arcs, uses only half the power of full wave rectification or, if the same total power is used, provides twice the current in each section when energized and results in electrical isolation of each half of the unit. This isolation prevents small arcs on one-half of the tubes from affecting the efficiency of the other tubes. The arrangement of the electrical equipment is shown on Figure 8.

One of the transformer and rectifier units is arranged for switching to any one of the three precipitator units. It serves as a spare and allows the shut down of any electrical unit for cleaning and maintenance.

The polarity of the d-c is controlled by a commutator on the shaft of the rectifier working in conjunction with two copper oxide rectifiers. In this way the directional or polarity control contactors controlling the primary circuit to the transformers are energized to give the correct discharge electrode polarity whenever the units are started. The equipment is provided with suitable overload protection and signals which indicate unintentional disruption of voltage to the precipitator.

It is unfortunate that operating figures to substantiate those listed as expected performance are not yet available. As was pointed out, all of the components of the superimposed units described have been proved in operation and the superimposed arrangement has given highly satisfactory operations elsewhere. It is hoped that operating figures for this installation can be published soon after the plant is placed in operation.

A MODERN *Ingot Heating* FURNACE

. . . . recognizing the importance of ingot heating, steel plants have installed a great many units of modern design in order to obtain better heating . . . .

by E. G. Smith, COMBUSTION ENGINEER
AMSLER-MORTON COMPANY
PITTSBURGH, PENNSYLVANIA

▲ AFTER the application of the Seimens regenerative principle to the soaking pit, few changes of major importance were made in furnace design or heating practice until comparatively recent years. Heating time in these furnaces was usually good and regeneration gave a measure of fuel economy. As a result, furnace design and heating practice alike became almost standardized and the defects of both came to be regarded as necessary evils.

For instance, it was often considered necessary to wash the ingots to remove surface defects, many of which were actually caused in the furnace by flame impingement. This practice not only reduced the yield, but in addition made it necessary to shut the pit down a considerable portion of the time for bottom making.

Flame impingement on the steel caused uneven heating and excessive localized temperatures that were reflected in high furnace maintenance and steel conditioning costs. Fuel rates were high because of the lack of combustion space in the furnace chamber, loose fitting covers which permitted air infiltration, and lack of combustion regulation. The quality of heating was a matter of the heater's judgment and varied from heat to heat with the ability of different heaters to observe the condition of the steel and determine when it was ready to roll.

From time to time improvements were made in covers, burners, reversing system and other auxiliaries but little change was made in the fundamental design and little progress was made toward a design of furnace that would meet modern requirements for fast heating and at the same time afford the quality of heating required by modern high grade steels.

Presented before A. I. S. E. Detroit District Section Meeting, April 13, 1943.

Our conception of the proper method of heating ingots was to provide a sealed combustion space in which adequate fuel could be burned in uniform relationship to all ingots without flame impingement. Temperature, combustion and pressure in the furnace chamber would be automatically controlled to assure precise duplication of heating quality on successive heats regardless of track time or weight of charge. Furnace gases would circulate freely and uniformly over the entire charge to insure the uniform heating. Washing would be eliminated and the scale would be light and dry and would fall off when the ingot is placed in the transfer car or on the mill approach table.

This concept was the basis of our design of modern ingot heating furnace, which employs a single burner firing upward from the center of the hearth. The surrounding ingots actually form the combustion chamber of the furnace and the hot gases leaving this chamber circulate among the ingots and downward to the hearth from where a portion is recirculated upward again by induction. None of the ingots are subject to flame impingement since the flame must travel parallel to the long axis of the ingot. None of the refractories are subject to maximum flame temperature and none are subject to the combined heating effect of flame and radiation from hot steel.

It is obvious that this furnace can employ the highest sustained flame temperature obtainable without endangering either the steel or the furnace refractories. Therefore, a high air preheat temperature is not only permissible but highly desirable from the standpoint of fast heating as well as fuel economy.

At the time this furnace was originally designed, the refractory recuperator as designed by our company had been in use on heating furnaces and furnaces for melting glass, silicate of soda and other non-ferrous materials

for a considerable time. In these melting furnaces temperature ran as high as 2850 F, and air preheat temperatures of 2150 F were not uncommon. This recuperator was incorporated in the new pit furnace design as an intimate part of the furnace structure so that radiation losses from the waste gases and preheated air are almost negligible. Preheat temperatures ranging from 1450 F with natural gas and oil to 1950 F with blast furnace gas have been recorded with respective stack temperatures ranging from 700 F to 1350 F.

This recuperator operates on the counterflow principle, with the waste gases passing downward through straight thin walled refractory tubes. The air which is supplied by a simple low pressure blower passes horizontally around the tubes and is directed upward by horizontal baffles which cause it to flow in alternate directions or passes to the top of the structure where it enters a collecting flue which communicates with the burner. Adjacent tubes are staggered to insure maximum turbulence and wiping action by the air. All joints are horizontal and held tight by the weight of the structure which is not bonded at any point to the enclosing walls.

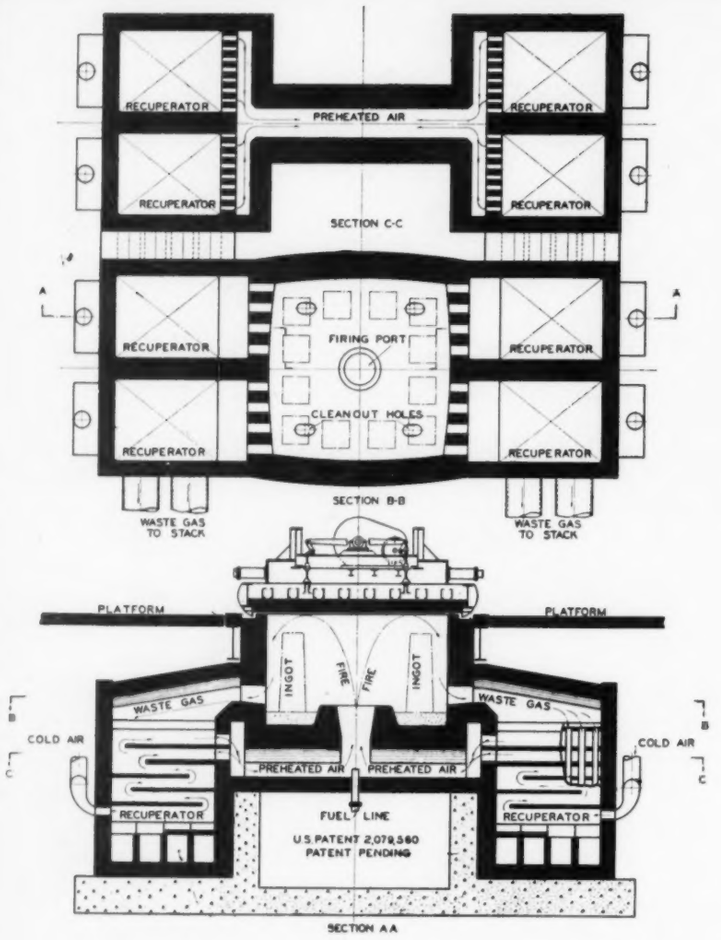
The single burner is of the nozzle mixing type and can be adjusted vertically to obtain the maximum flame temperature at the top of the port near the butts of the ingots. Any gaseous or liquid fuel can be used selectively without change in the furnace structure and without impairing the heating characteristics of the furnace.

The tight sealing cover, vertical lift cover carriage, complete automatic control and automatic fuel shut-off during cover operation were pioneered and patented in the pit furnace design. The cover is a rigidly braced steel framework suitable for supporting any standard suspended arch and is equipped with a series of alloy steel seal castings around the lower periphery, which engage a deep sand filled trough around the pit curb when the cover is lowered into place. This device seals the pit positively against flame "stingout" around the cover when the furnace is operated at positive pressures of 0.1 in. water column and higher.

The cover carriage is designed to lift the cover vertically from the seal, then traverse it in either direction so that it is unnecessary to completely uncover the pit when charging or drawing ingots.

Fuel, air and draft are automatically shut off when the cover starts to lift from the seal and automatically turned on again as soon as the cover is lowered into place. These operations are almost instantaneous and are so synchronized with the cover movement that the pit atmosphere is cleared to permit ingot handling as soon as the cover is traversed. Heating is resumed at full fuel flow and under full automatic control two seconds after the cover is lowered into place. Where a large number of small ingots are rolled from the pit at intervals of two minutes or less, this fast fuel shut-off and recovery maintains the temperature at control point so that the last ingot is rolled at the same temperature as the first.

Temperature is controlled at approximately 2400 F from a thermocouple or radiation unit located in the end wall of the pit slightly above the top of the ingot. With temperature measurement at this point it is obviously impossible for the steel temperature to exceed a predetermined limit at any time during the heating cycle and the quality of heating can be precisely duplicated in successive heats regardless of the charging



Plan and elevation of non-reversing recuperative furnace for heating ingots.

temperature of the steel, firing rates or weight of charge.

The centrally located burner and symmetrical construction of the waste gas exhaust system maintain a balanced flow of furnace gases to all parts of the furnace chamber at all firing rates throughout the heating cycle. Furnace pressure and air gas ratio control can therefore operate through the entire cycle to hold their respective functions at the original value without adjustment or resetting to compensate for flow conditions which change with the reduction of firing rate.

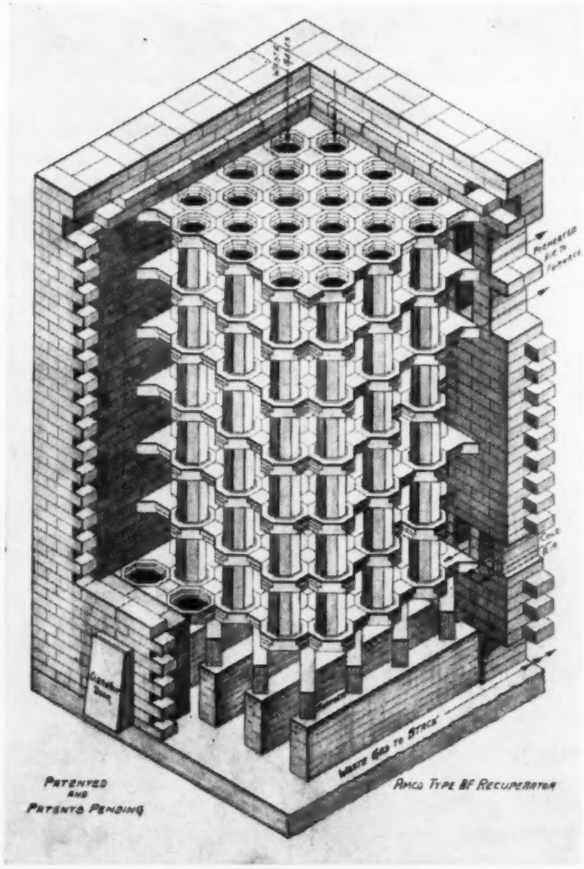
In this furnace, hot charged steel is being heated to rolling temperature in a net heating time equal to the time from finish of pouring at the open hearth to charging into the pit at a fuel rate of approximately 100,000 Btu per ton per hour of track time. In other words, if the steel has been on the track three hours it will be ready to roll three hours after charging into the pit and the fuel rate will be 300,000 Btu per ton.

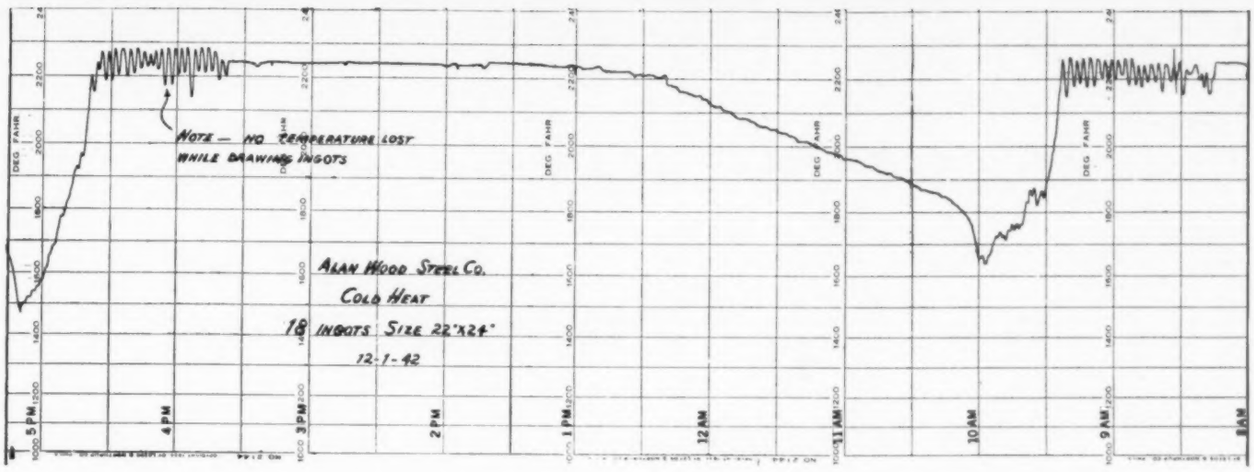
Banked cold ingots are being heated at the rate of twenty to twenty-five minutes per inch of thickness at a fuel rate of 1,100,000 Btu per net ton on the basis of net heating time. Fast uniform heating in a controlled furnace atmosphere has reduced scale and crop losses to the point where the yield from modern pits is 2 to 3 points greater than that shown by previous heating practice in the same shops.

This furnace attains its maximum heating rate in tons per hour at 30 to 40 per cent hearth coverage. Considerable research in large shops and with a variety of types of furnaces has proven this range of coverage to be normal for good ingot heating practice and heavier loading can be justified only from the standpoint of ingot storage. In other words, the heating rate of a pit and its storage capacity are distinctly separate considerations because fast heating is not attainable unless there is sufficient space between ingots to permit free circulation of the furnace gases. This phase of soaking pit practice was discussed in detail by F. E. Leahy, in his paper "Comparison of Soaking Pit Designs" (A.I.S.E. Yearbook 1941, p. 400).

By eliminating washing in the pit, bottom making intervals have been extended to approximately ten days to two weeks with coke additions at intervals of three to four days during continuous operation. The total delay required by a new bottom is usually 1½ to 2 hours, including the time required for burning in the fresh coke. Where it has been possible to segregate the cinder from the various pits, the quantity from the modern pits has varied from one to two pounds per

General arrangement of refractory recuperator applied to ingot heating furnace.





Temperature record from ingot heating furnace under automatic control.

ton of steel heated and included such a small amount of metallics that recovery processing was impracticable.

The first ingot heating furnace of the type discussed here was placed in operation in the early part of 1936 and since that time one hundred and seventy-one have been placed in operation or are contracted for. Every type of gaseous and liquid fuel has been used and in all cases with a full complement of automatic controls. Practically every type of steel from low carbon to high alloy electric furnace grades have been heated successfully at fuel, maintenance and labor costs that permit quick amortization of the investment.

That steel plant engineers and furnace operators generally appreciate the value of this modern ingot heating furnace as a tool for making more and higher quality steel, is evidenced by the fact the current expansion program includes pits of this design which will have, upon completion, a heating capacity of 8,500,000 tons per year.

DISCUSSION

PRESENTED BY

H. E. PHELPS, Superintendent, Electric Furnace Department, Rotary Electric Steel Company, Detroit, Michigan

W. H. COLLISON, Superintendent, Coke Plant, Blast Furnace Division, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

L. R. MILBURN, Electrical Engineer, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

M. R. SCOTT, District Engineer, Linde Air Products Company, Detroit, Michigan

P. M. OFFILL, Vice President, Amsler-Morton Company, Pittsburgh, Pennsylvania

H. C. HOEFT, Electrical Designer, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

F. C. FRYE, Steam and Fuel Engineer, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

W. E. REIBER, Assistant Chief Electrician, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

E. G. SMITH, Combustion Engineer, Amsler-Morton Company, Pittsburgh, Pennsylvania

H. E. PHELPS: I would like to ask a question. I believe I understood you to say that the heating time is equal to the track time. Would that be true regardless of the size of the ingot?

E. G. SMITH: That is always true on large ingots as well as small ingots.

W. H. COLLISON: Mr. Smith, do you have any trouble with cross leakage, or leakage between the air and the flue gas sections of the recuperators? How well do the recuperators stand up in that respect?

E. G. SMITH: All recuperators have a certain amount of cross leakage. However, our recuperator has virtually 100 per cent horizontal joints which reduces the cross leakage to a point where it is of no consequence.

With a few exceptions where recuperators were mistreated our recuperators have not been replaced over a period of six years.

W. H. COLLISON: What materials are in those refractory tubes?

E. G. SMITH: Fire clay of super-duty quality or silicon carbide.

L. R. MILBURN: On the conventional soaking pit, or older model pit, is anything gained in heating time by sealing the covers?

E. G. SMITH: The conventional soaking would be definitely helped by sand sealing the covers. The object of sealing the cover is primarily to permit control of furnace atmosphere.

(Please turn to page 85)

Improvements IN THE HOT PROCESS *Water Softener*

. . . . steady advance in the design and application of the hot process softener has made it the most versatile means of conditioning for boiler feed water . . . .

by C. E. Joos

COCHRANE CORPORATION

PHILADELPHIA, PENNSYLVANIA

▲ THE hot process water softener had its beginning at the turn of the century. Soda ash was fed into an oversized open feed water heater to bring about partial precipitation of hardness. The treated water was passed through a filter consisting of coke or similar material in burlap bags placed in the storage space of the heater. (Figure 1.)

From this very crude beginning, the design of equipment was steadily improved, and the number of chemical reagents used in the process increased. The feeding of lime in addition to soda ash was adopted in 1912, and these became the standard reagents until 1928. Since that time the efficiency of the process has steadily increased to meet the more exacting requirements of boiler manufacturers and engineers, made necessary by the higher pressures, greater steaming capacity, and smaller tubes of the modern steam generator.

This progress has kept pace with the industry, and at the present time units are in service preparing feed water for boilers operating at pressures as high as 1400 psi, delivering water of zero hardness, with controlled alkalinity and silica concentration. The modern version of the hot process softener is illustrated in Figure 2, representing a unit capable of softening and deaerating boiler feed water at a rate of 1,250,000 lb per hour.

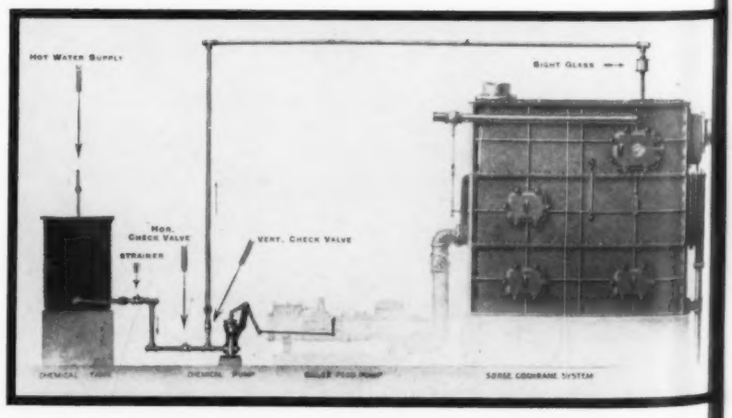
Many mechanical improvements have been incorporated in the apparatus in the past several years which have led to increased efficiency and lower cost of the equipment, maintenance and operation.

Tray heaters have been replaced by jet heaters, which spray the water into an atmosphere of steam, eliminating the problem of deposition of carbonate deposits on the trays, thus reducing maintenance costs.

Deaerating apparatus has been incorporated as part of the unit, eliminating the necessity of installing separate equipment for this purpose. This design was made possible by the development of a new means of deaeration employing the principle of dividing the preheated water into a very fine mist by a high velocity steam jet. This deaerating atomizer is somewhat similar to a steam atomizing oil burner and has the advantage of remaining free of deposition that would occur in the tray type of heater deaerating unfiltered softened water.

The development of a stirring device has aided in improved flocculation by bringing about an intimate mixture of chemicals and agglomerating the resulting

Figure 1 — The hot process water softener in 1906.



precipitate. Figure 3 illustrates the approximate relationship between the speed of the stirring mechanism and the suspended matter in the effluent. It is worthy of note that when properly designed, this equipment reduced the suspended matter to 6 ppm, results which are much better than apparatus not so equipped.

Electrically operated chemical feeds have been incorporated to simplify the regulation of chemicals for the operating engineers. Modern equipment employs separate chemical tanks for the individual reagents, and the increase or decrease in chemical feed becomes as easy as changing a radio-dial. Furthermore, it permits the use of a standardized chemical charge, simplifying charging of the chemical tanks.

Filters have been improved so that with large installations the back-washing operation employs the use of filtered water, reducing the number of valves on the individual filters from 5 to 3 or 4. The use of filtered water for back-washing also eliminates the necessity of rinsing the filter of unfiltered water.

Designs have been made for carrying out the filter washing operation automatically by the use of program timers and hydraulic or pneumatic valves, making the entire process automatic, with the exception of charging the chemical tanks once every 12 or 24 hours.

Controls for automatic sludge blowoff from the sludge-cone have been developed. This can now be accomplished automatically in proportion to the flow of makeup water. A pilot actuated diaphragm valve is opened by an electric contact on the raw water meter, the duration of the opening being governed by a timer. A simple adjustment of this timer, located on a panel-board, provides an easy means of increasing or decreasing the blow-down schedule.

Means of recirculating sludge have been incorporated in order to bring about more intimate contact of the magnesium precipitates with the water for the reduction of silica.[1] This recirculation of sludge can likewise be arranged for automatic operation in proportion to the flow of makeup water.

Temperatures of operation have steadily increased to the upper limit of 50 psi with more efficient operation bringing about a substantial saving in chemicals. Figure 4 illustrates the hardness reduction at 210 F and the greater reduction obtained at 295 F.[2]

CHEMICAL REAGENTS

From the early use of soda ash as the sole water conditioning reagent, the following chemicals are now quite generally used. One or more of these chemicals may be applicable depending upon the nature of the water and the results desired, and in some cases as many as four or five chemicals may be used as the primary and supplementary treatments.

Soda-ash is used to precipitate non-carbonate hardness and provide excess alkalinity.

Lime is most commonly used in the hydrated form and serves the purpose of precipitating the bicarbonates and magnesium. Pebble lime serving the same purpose is used in dry feeding equipment which incorporates a lime slacker, and because of its lower cost it is used in some large installations.

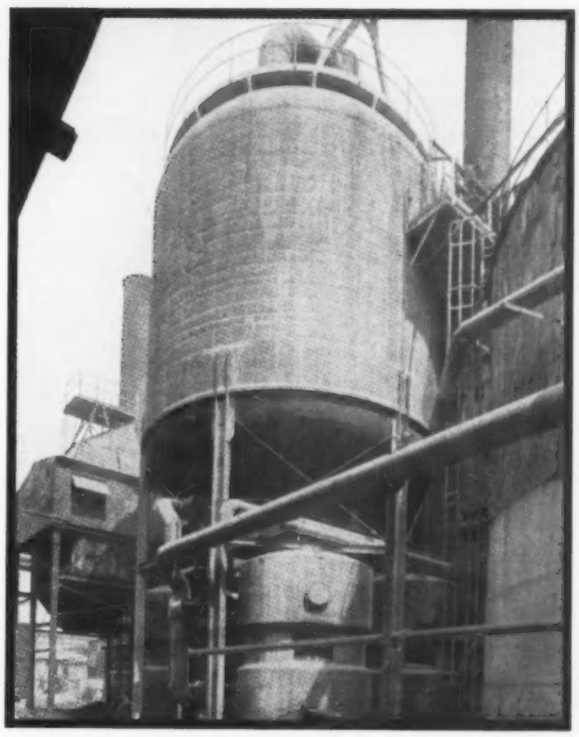
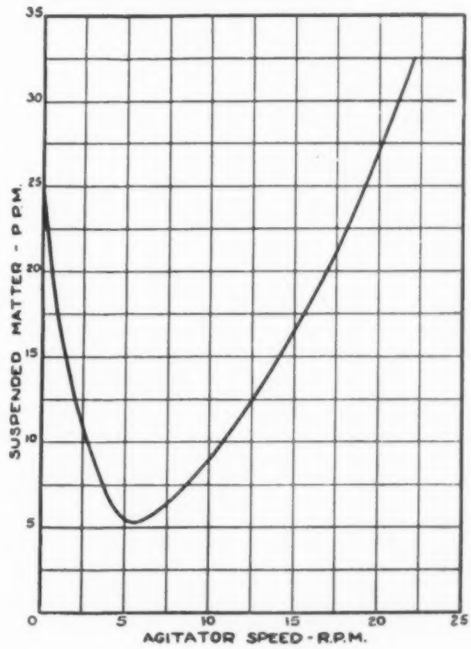


Figure 2 — Modern deaerating hot process softener, capacity 100,000 gal per hr.

▲

Figure 3 — Relation of speed of stirring mechanism to suspended matter and the effluent of the hot process water softener sedimentation tank.



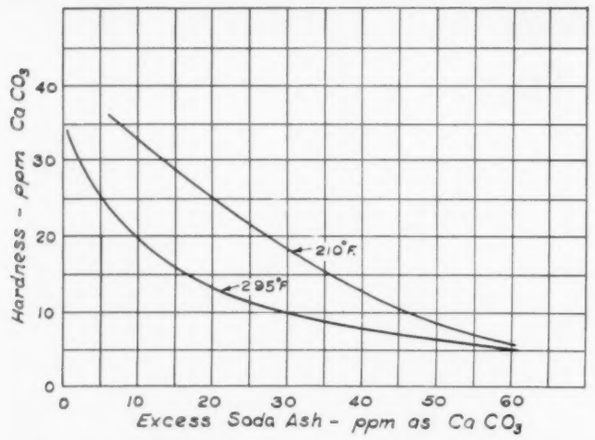


Figure 4 — Relationship between excess sodium carbonate and hardness at temperatures 210 F and 295 F.

Dolomitic lime, consisting of calcium hydroxide and magnesium oxide, serves the same purpose as the hydrated and pebble lime, in addition to which the magnesium is used to adsorb silica. It is used as a substitute in whole or part for hydrated lime where silica is to be reduced to low quantities.

Phosphates may be used either as primary treatment (in the water softener proper) or as a supplementary treatment (following the filters). The following varieties have common usage:

Phosphoric acid
Monosodium phosphate
Disodium phosphate
Trisodium phosphate
Hexametaphosphate

Caustic soda is used with phosphoric acid to precipitate calcium as tri-calcium phosphate and magnesium as the hydroxide.

Magnesium sulphate is used principally for the adsorption of silica, particularly in a phosphate softener, and may also serve the purpose of reducing natural sodium carbonate alkalinity.

Magnesium oxide is used as a coagulant and absorber of silica.

Ferric sulphate may be used as a coagulant to aid flocculation of suspended matter in the treatment of highly turbid waters or in phosphate softeners.

Sulphuric acid is occasionally used to form gypsum by reaction with lime, serving the purpose of reducing natural sodium carbonate alkalinity. Also, it is fed to raw water for the reduction of natural sodium carbonate in treating well waters high in this constituent.

For controlling the alkalinity and pH values from hot process softeners to give protection against deposition in stage heaters or economizers, it is fed to the effluent from the filters.

Gypsum is used in treating well waters high in natural sodium carbonate and brings about its reduction with the formation of the by-product of sodium sulphate.

Chloride of lime is used for its chlorine content as a substitute in part for hydrated lime to oxidize such contaminants as ammonia.

APPLICATION OF PROCESS BROADENED

While lime and soda ash continue to be the principal primary reagents, the use of other chemicals have broadened the scope and application of the apparatus and increased its efficiency, and units have been applied to water conditioning in which softening has been secondary to other objectives.

With the use of dolomitic lime, magnesium oxide or magnesium sulphate the process is ideally suited for the reduction of silica, a constituent which, in many cases, if left uncontrolled, may be causative of hard dense boiler-scale and turbine-blade deposits.

Years ago it was noted that a considerable silica reduction was brought about in many plants by the use of lime and soda ash alone. Investigation showed this was due to the precipitation of the magnesium salts naturally present in the raw water supply. The fact that this reduction was proportional to the magnesium content led to the fortifying of the raw water supply with a magnesium salt, if the desired reduction was greater than that which could be obtained with that initially present. The silica reduction in the treatment of water supplies having appreciable magnesium content using lime and soda ash treatment is illustrated by Figure 5.

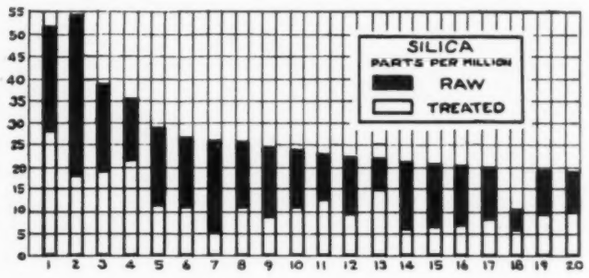


Figure 5 — Reduction of silica by lime and soda ash treatment.

The first hot process water softener in which these findings were utilized specifically for silica removal, was installed in 1939. Water under treatment contained but 15 ppm of hardness with a silica concentration of approximately 20 ppm, which caused considerable trouble with silicious boiler scales. Use of magnesium sulphate and caustic soda as the precipitating reagent brought about a reduction in silica in this plant to less than 3 ppm.

Since this installation, other magnesium compounds have been used with success, principally, dolomitic lime in conjunction with lime and soda ash.

Since silica is removed by adsorption, it is necessary to present large surfaces for intimate contact, and for this purpose the settled sludge is recirculated to the top of the reaction chamber, by this means reducing the chemical requirements by approximately 25 per cent or more.

USE OF PHOSPHATE AS PRIMARY TREATING AGENT

Up until 1931 the hot process softener was unsuited to the treatment of soft water supplies without the addition of excessive quantities of soda ash. This was objectionable due to the high alkalinities and the substantial increase in total solids, necessitating a high rate of boiler blow-down for their control.

Figure 6 — Sample of boiler water concentrate after 1220 hr of steaming shown in bottle at left. That at the right contains distilled water.

The use of phosphates as the primary treating agents greatly increased the efficiency of the softening process, and for the first time hardness could be reduced to zero with reasonably low alkalinities. The use of trisodium phosphate[3] for this purpose gave way to phosphoric acid[4], as it provided a means of reducing the alkalinity, the CO_2 in the generated steam, and the cost of treatment. The removal of practically all calcium and magnesium from the boiler resulted in a sludge-free boiler concentrate producing cleaner steam and cleaner boilers.

Figure 6 is an unretouched photograph of a sample of distilled water compared with the boiler concentrate after 1220 hours of steaming, illustrating the remarkable efficiency of the process in reducing hardness. Installations indicate this reduction may be brought about to a figure as low as ½ ppm.

REDUCTION OF NATURAL SODIUM CARBONATE

Well waters in southern Texas, Louisiana, southern California and central Illinois frequently contain relatively large quantities of "free" sodium carbonate along with hardness and high silica. These waters likewise usually are low in sodium sulphate. Sodium carbonate is effectively reduced by the use of gypsum or sulphuric acid; gypsum being fed along with softening reagent of line and/or dolomitic lime and has the advantage of simplicity.

The gypsum reacts with the sodium carbonate precipitating the carbonate as calcium carbonate and forming the soluble by-product of sodium sulphate.

The cost of this treatment may be reduced by the introduction of sulphuric acid into the raw water followed by a decarbonator for the removal of the generated carbon dioxide from the water prior to softening. This cost reduction is brought about by removal of carbon dioxide mechanically instead of by chemical precipitation.

REMOVAL OF ORGANIC MATERIAL AND AMMONIA

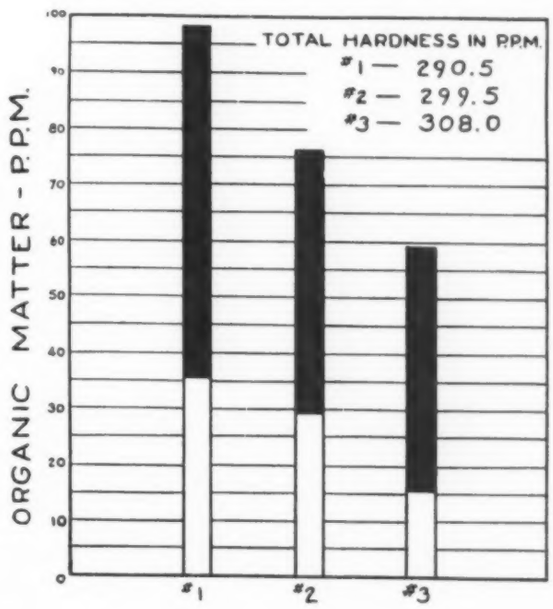
The scouring action of hot process softener precipitates effectively reduce organic matter introduced through contamination by sewage and industrial wastes. Figure 7 illustrates reduction taking place in three plants taking their water supply from a highly polluted stream.

Occasionally the water supply may contain small quantities of ammonia. Ammonia is used in addition to chlorine for sanitary purposes in municipal treating plants, so that a water from this source may contain ammonia. It may also be present due to contamination of surface waters by industrial wastes.

Ammonia is objectionable because of the destructive effect it has on copper and some of its alloys, and the generation of free ammonia with the steam frequently has caused serious deterioration of stage heater and condenser tubes.

The elimination of ammonia in one hot process softener installation has been accomplished by substituting chloride of lime for a portion of the lime used as the softening reagent. The available free chlorine oxidizes the ammonia to nitrogen, which is inert.

Figure 7 — Illustrating reduction of organic matter in three plants utilizing lime and soda ash treatment.



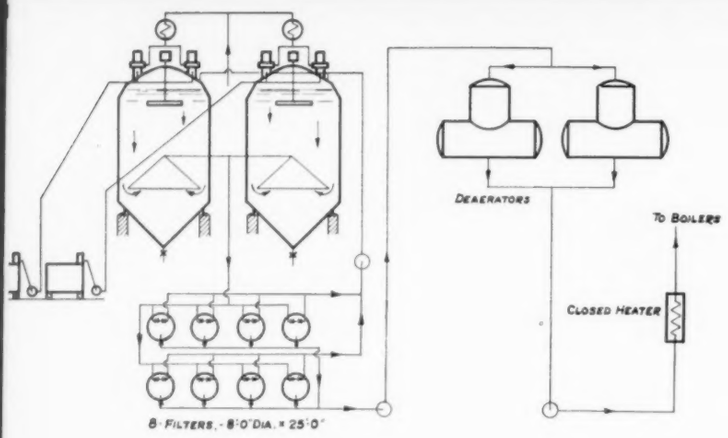


Figure 8 — 320,000 gal per hr double unit hot process softener serving 900 psi boilers in a large steel plant.

SOME TYPICAL INSTALLATIONS

As examples of the improvements in the apparatus and the applications of chemical treatment, several flow diagrams are illustrated representing a few of the many types that are in service. The softener is designed specifically for each job, the controlling design factors being the quality of the raw water, the results desired, and the investment cost.

Lime, soda ash and supplementary phosphate treatment — This installation (Figure 8) is the largest unit of its kind in the world, having a total capacity of 320,000 gal per hr, preparing makeup for 900 psi boilers in a large steel plant.[5]

While the first unit at this plant was installed in 1926, it was modernized by the installation of a second unit in 1941, incorporating some of the later developments. Stirring mechanisms were installed in the sedimentation tank to bring about better flocculation of the precipitate, and filters were revamped to simplify the valve arrangement. Eight horizontal filters 8 ft 0 in. in diameter by 25 ft long, arranged in double-deck fashion to save floor space, are provided with only three valves apiece. By placing the back-wash pump beyond the filters, instead of ahead of the filters, it becomes possible to back-wash with filtered water, greatly simplifying the valve nest.

Independent units deaerate the softened, filtered water and the supplementary treatment of phosphate is pumped directly to the boilers.

Double deck filters and chemical feeds save space — Figure 9 illustrates flow diagram of a 100,000 gal per hr unit, for conditioning practically 100 per cent makeup water for 900 psi boilers. This installation incorporates deaeration, double-decking of the chemical feeds to save space, and double-decking of eight 11 ft diameter vertical filters. This double-decking arrangement is better visualized by reference to Figure 2. Filtered water back-wash is incorporated, and the chemical feeds are of the electrically operated type, controllable from the panel-board.

This installation operates in conjunction with an older unit installed in 1925, which is of the non-deaerating type, and the effluent from the sedimentation tank is delivered to the deaerator in the new sedimentation tank joining the main body of makeup water.

While the softening capacity of the new unit is 100,000 gal per hr, the deaerating and filtering capacity is 1,250,000 lb per hr.

The treatment is lime and soda ash as the primary reagents, with supplementary treatment of phosphate fed directly to the boilers.

Phosphoric acid treatment with cold process softened water — This unit is used to condition the effluent from a cold process softener. Figure 10 illustrates the hot process water softener, which takes its water supply from an existing cold process softener of the intermittent batch type. The raw water supply is a highly contaminated surface water and is treated with caustic

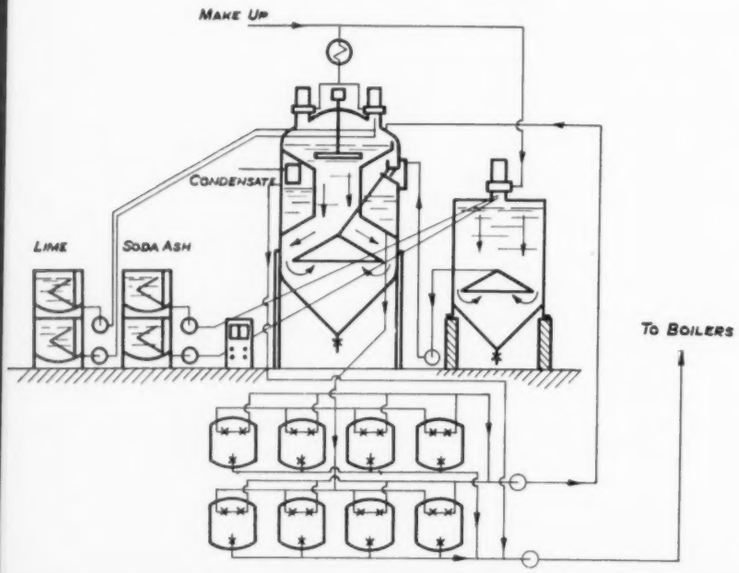


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Figure 9 — 100,000 gal per hr deaerating hot process water softener having deaerating and filtering capacity of 1,250,000 lb per hour.

Figure 10 — Phosphate softener utilizing phosphoric acid in treatment of cold process softened water.

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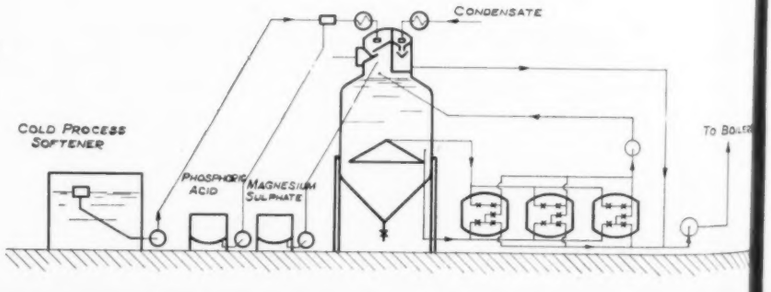


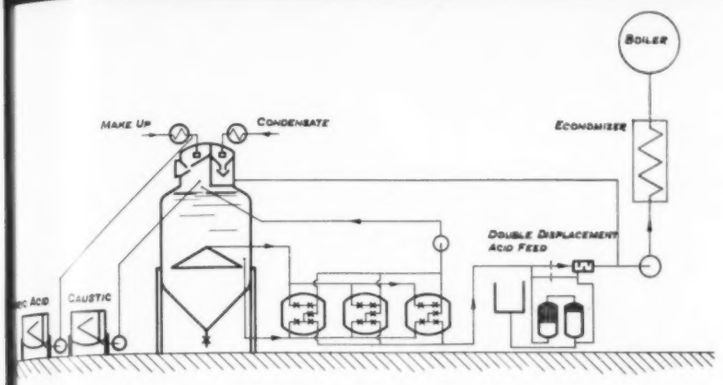


Figure 11 — Phosphate softener treating contaminated condensate for 1400 psi boiler plant.

soda and lime, hardness being reduced to the order of 10 ppm. This water is treated with phosphoric acid, subsequently deaerated, and settled for reduction of the hardness to zero. The unit contains a separate heating and deaerating section for the condensate.

The chemical feeds are so arranged that magnesium sulphate may be utilized for the adsorption of silica. In the event of shutdown of the hot process softener, the chemical feeds are arranged for pumping phosphate directly to the boilers in the interval. This installation has produced a feed water of zero hardness and crystal-clear boiler concentrate.

The design is such that it also provides considerable storage of hot deaerated water for emergency service.

The filter valve nest is arranged so that the rinse water may be returned to the sedimentation tank without wastage of heat.

A hot process water softener applied to treatment of condensate — This installation, Figure 11, is interesting in that it treats contaminated condensate containing hardness to the extent of 10 to 20 ppm; condensate being returned at 165 F makes the phosphate process ideally suited. Previous to the installation of this equipment, internal treatment by phosphate resulted in sludge deposition, causing frequent boiler outages. Similar to Figure 10, the phosphoric acid is added ahead of the softening equipment, the water subsequently being deaerated and treated with caustic soda. Water is reduced to zero hardness and has a pH value of the order of 9.5 to 10. The effluent from the filters is treated with sulphuric acid to reduce the alkalinity and pH value. Recently, phosphoric acid was substituted for the sulphuric acid.

This installation has been highly successful, eliminating all of the sludge in the boiler concentrate, making it unnecessary to remove the boilers from service for internal cleaning.

Two-stage hot process water softener — The unit illustrated by Figure 12 is the largest two-stage hot process softener in the world, having a total capacity of 120,000 gal per hr. This plant uses Lake Michigan water, treating this with primary reagents of lime and soda ash. The effluent from the first stage, containing hardness of approximately 17 to 20 ppm, is treated in the second stage with disodium phosphate to reduce this hardness to zero. Water is subsequently filtered and deaerated by an independent deaerator.

Both sedimentation tanks are provided with stirring mechanisms. The filters use the four-valve arrangement, filtered water being pumped from the filtered water main as a means of back-washing.

The unique feature of this installation is the proportioning of recirculated boiler water. The boiler blowdown water is passed into a flash tank and a portion of the flashed blowdown water is proportioned to either the first or second stage, depending upon the operating conditions. The remainder of the blowoff water passes through a heat exchanger to waste. The proportioning control operates from a raw water meter, the opening of the valve being at all times proportional to flow.

Treatment with high excess of sodium carbonate and subsequent reduction with sulphuric acid — This installation, Figure 13, having a capacity of 200,000 gal per hr, utilizes a relatively high excess sodium carbonate in order to reduce the hardness to low limits (see Figure 4). Following filtration, this excess is reduced by the

Figure 12 — Two-stage hot process water softener, largest of its kind in the world, having total capacity of 120,000 gal per hr.

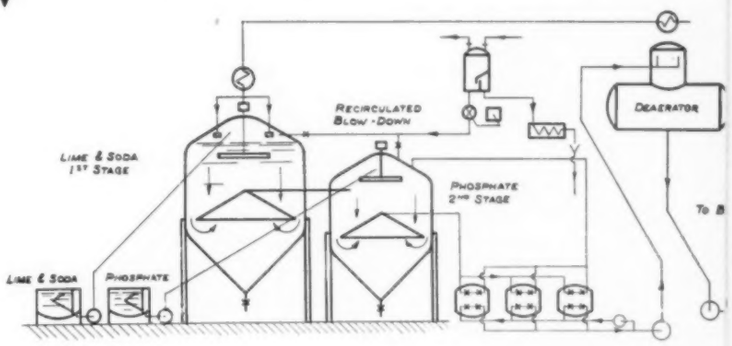
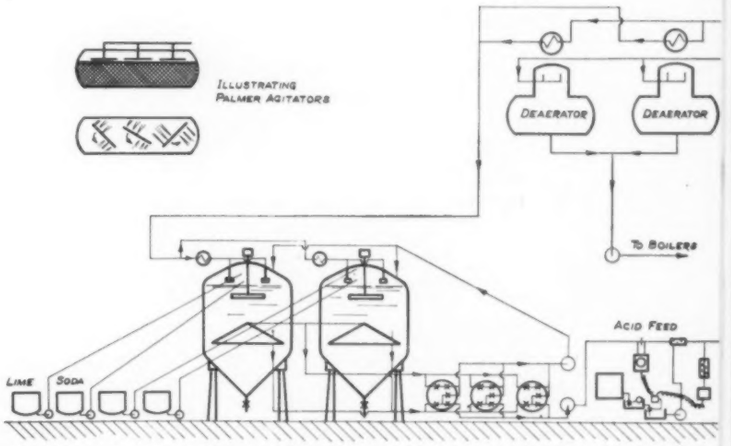


Figure 13 — 200,000 gal per hr hot process water softener utilizing high excess of sodium carbonate for reduction of hardness and after treatment of sulphuric acid for alkalinity control.



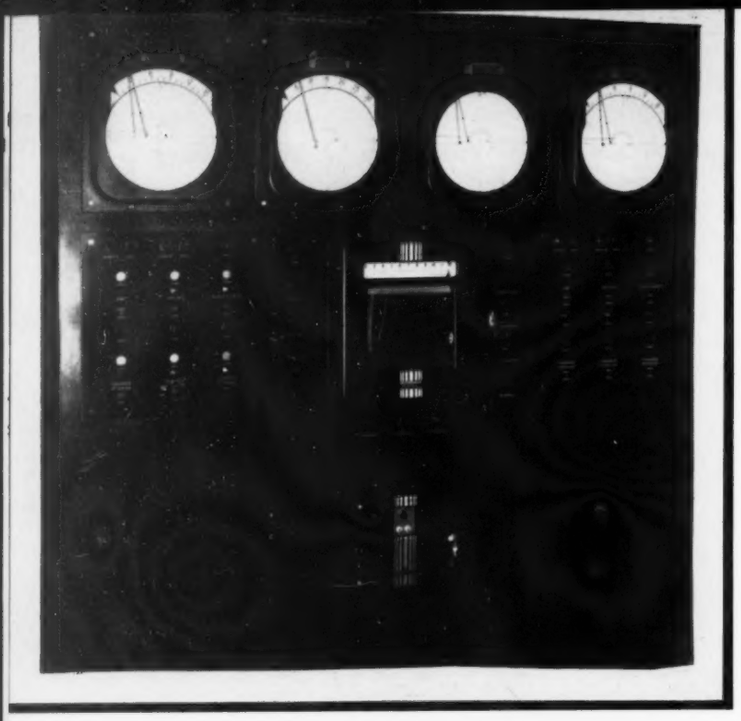


Figure 14 — Panel board for control of water softener illustrated in Figure 13, incorporating flow meters, level controllers, sulphuric acid proportioning equipment, high and low level alarms, etc. Control of entire water conditioning equipment is from this panel board.

introduction of dilute sulphuric acid. The unique feature of this acid feed is that it is controlled by an electric flow meter continuously and instantly in direct proportion to the flow of feed water, and it includes supplementary pH control for maintaining a constant pH value. The flow meter proportions the acid according to the flow, whereas the pH controller adjusts the feed for changing pH values. The water is subsequently deaerated through independent tray-type deaerators.

Filters are provided with agitators which rotate and spray high pressure water jets on the surface of the filter bed, facilitating the cleansing operation. Individual chemical tanks are provided for each chemical and all of the controls are mounted on a common panel-board on which are also located level indicators and high and low level alarms used in connection with the controls; this is shown by Figure 14.

This steady advance in the design and application of the hot process softener has made it the most versatile means of water conditioning available for conditioning boiler feed, and because of its versatility it has had wide acceptance by engineers and designers.

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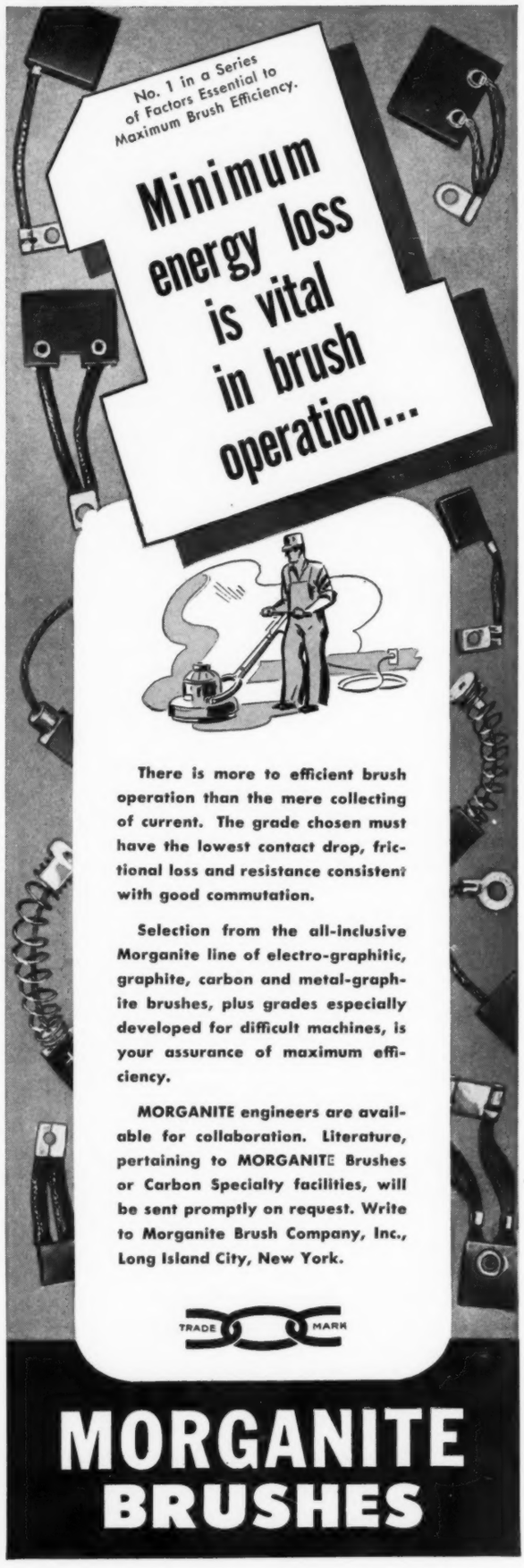
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by C. A. Kotterman AND
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FEDERAL TELEPHONE AND RADIO CORP.
EAST NEWARK, NEW JERSEY

▲ MOST common substances we are familiar with are either insulators or conductors of electricity. There are a few materials, however, that lie in the borderland between insulators and conductors. These are known as semi-conductors. The chemical element selenium belongs to this class of materials. Selenium was discovered in 1817 by Berzelius, a Swede. He observed a red, powdery-like deposit on the floors of the lead chambers used in the manufacture of sulphuric acid. Preliminary examination led him to believe that the material was tellurium. After further study of the unknown substance, he reached the conclusion that, while the material possessed properties resembling tellurium in many ways, it was not tellurium but a new unidentified element. Because of the close resemblance of the unknown chemical to tellurium, he called the new element selenium from the Greek "selene" which signifies the moon, while "tellus" is the name of our own planet. Selenium is widely distributed in the earth's crust but exists only in small quantities. It usually occurs with tellurium and sulphur, in combination with pyrites, particularly copper pyrites, and many other minerals. The most copious supply of selenium in this country comes as a by-product of the manufacture of sulphuric acid. Fortunately, it is not on any preferred list of materials at the present time and a priority is not needed for its purchase.

There are three forms of selenium: the vitreous form which is almost an electrical insulator; the alpha form which is crystalline, but has a high specific electrical resistance; and the beta form which has a lower resistance. Selenium has a very remarkable property which contributes considerably to the excellent electrical characteristics of the selenium rectifier — its specific electrical resistance decreases with temperature rise!

In order to understand how this property of selenium influences the behavior of the selenium rectifier, it is necessary at this point to consider the difference between a symmetrical and an asymmetrical conductor.

When a voltage is applied to a conductor comprising a single substance, the current which flows is independent of the polarity of the voltage. For instance, consider a piece of ordinary resistance wire which has a d-c voltage applied to it. The current flowing in the wire obeys Ohm's law and it is the same regardless of the polarity at the ends of the wire. Such a conductor exhibits symmetric conduction. This law is generally obeyed by composite conductors, but in certain physical or chemical combinations the current varies according to the direction in which it is passing and the combinations are said to exhibit asymmetric conduction, which can be defined simply as the ability of the combination to pass current more freely in one direction than in the opposite direction. The diode vacuum tube is probably the best-known example of a physical arrangement which may be used for rectification. The direction in which current is passed more freely is usually called the "forward" or "conducting" direction, and the other the "reverse" or "blocking" direction.

An essential property of all metal-plate rectifiers is that they possess asymmetric conductivity. In such rectifiers, rectification occurs at the contact surface between two dissimilar substances, usually referred to as a conductor and a semi-conductor.

The earliest published matter which can be traced relating to asymmetric conduction is that attributed to

Presented before A. I. S. E. Chicago District Section Meeting, April 16, 1943.

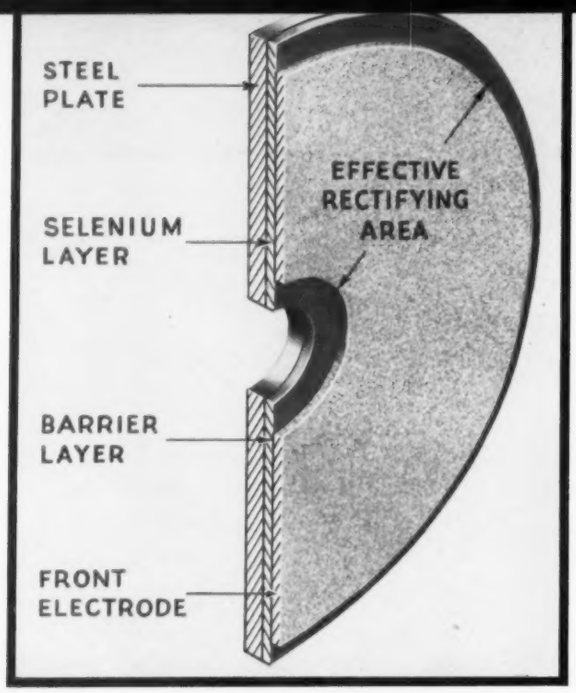


Figure 1 — Cross section of selenium rectifier plate.

Braun who, in 1874, noticed that the resistances of certain metallic sulphides appeared to vary with the direction and magnitude of the current passed through them. In the same year Schuster observed an irregular change of resistance according to direction of current flow in a simple circuit consisting of short pieces of copper wire linked together by terminals. Schuster realized that the irregularity was due to some property of the contacts, and Braun showed later that this also applied to his sulphides and to the asymmetry of selenium noticed at about that time by Siemens, who was studying the light sensitivity properties of that element. It was soon discovered that certain electrolytic cells showed asymmetry and, in 1878, Braun proved that this was due to some peculiarity in the surface condition of the electrodes.

In 1883 Fritts published details for the construction of a new form of selenium light sensitive cell and described it as "a metal plate upon which the selenium was melted and with which it forms chemical combination sufficient to cause the selenium to adhere and make good electrical contact. The other surface is not so united or combined, but is left in a free state, and a conductor is subsequently applied over it by simple contact or pressure. During the process of melting and crystallization, the selenium is compressed between the metal plate upon which it is melted and another plate of metal or other substance with which it will not combine. Thus the simultaneous application of heat, pressure, chemical affinity and crystallization form it into a sheet of granular selenium. The cells so produced showed marked polarization (asymmetry), and in some cases ratios as high as 256 to 1 were observed."

The physical make-up of a typical selenium rectifying couple or junction as we know it today is shown in Figure 1. A layer of vitreous selenium, the semi-conductor, is applied to a metal base plate, usually of iron. The thickness of the selenium layer is between 0.002 and 0.004 in. Subsequent processing converts the vitreous selenium into the beta or semi-conducting form. A layer of metal alloy is then sprayed onto the surface of the selenium. This creates a barrier layer between the two contacting interfaces. This layer is exceedingly thin, measuring approximately 0.000004 in. in thickness and, while it is an insulator, it permits electrons to pass freely in either direction. It will be seen that our rectifying couple now consists of a barrier layer sandwiched between a conductor and a semi-conductor. The metal layer contains an abundant supply of free electrons. The selenium possesses only a meager supply of free electrons. If we now connect the couple to a source of d-c electric supply, the opposite polarities will set up an electric field across the barrier layer. Since this layer is

Figure 2 — Typical static resistance-voltage curve of selenium rectifier plate with an effective surface area of one sq cm.

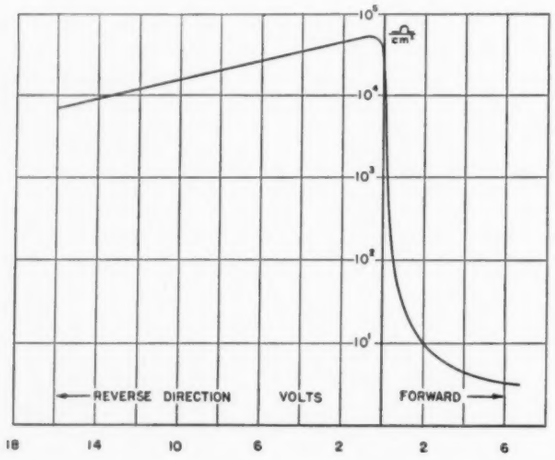
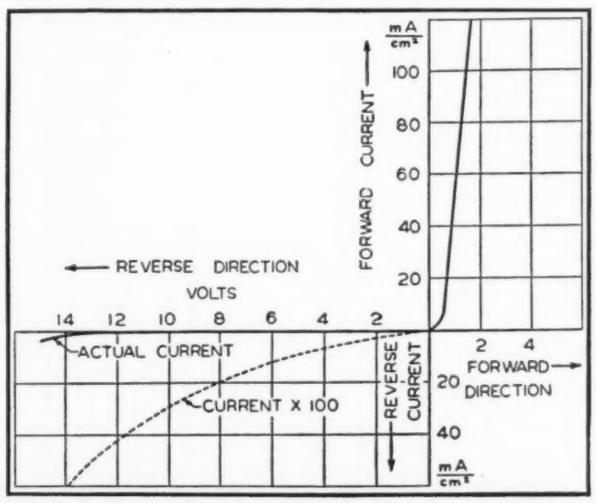


Figure 3 — Typical static forward and reverse current characteristics. (Reverse characteristics shown to two scales.)



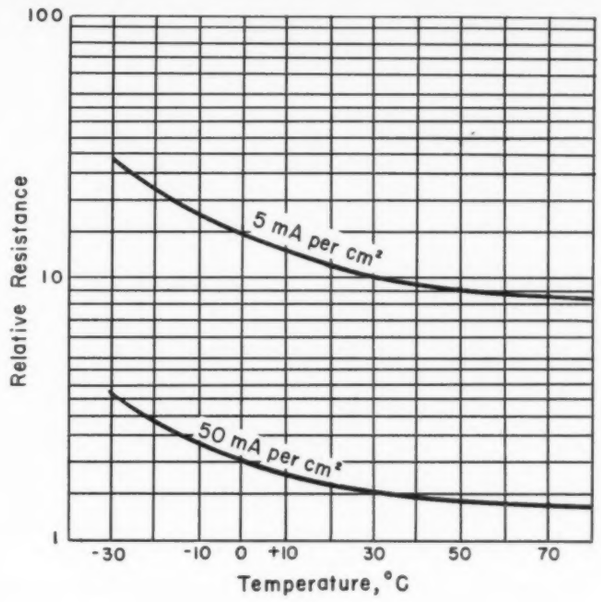


Figure 4 — Variation of forward resistance with temperature.

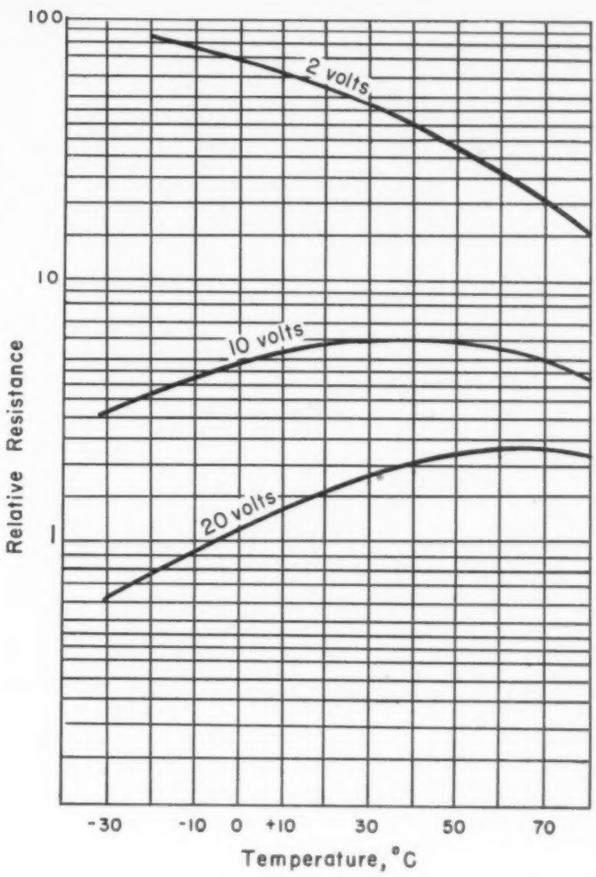


Figure 5 — Variation of reverse resistance with temperature.

extremely thin, a small emf will produce a steep potential gradient. If the sprayed metal layer is made negative with respect to the selenium side, the free negative electrons are accelerated to a sufficient velocity by the field to pass through the barrier layer into the intercrystalline spaces of the selenium and reach the supporting base plate, establishing a flow of electrons which constitutes a current of electricity in the forward direction or from the supporting plate to the sprayed layer. Upon reversing the polarity, the same action takes place in the opposite direction, but as the number of free electrons in the selenium layer is very much less than in the metal, the resulting current is very much smaller.

The resistance of the metal plate rectifier in either the forward or reverse direction is dependent upon the applied voltage; that is, it does not follow Ohm's law. The variation of resistance with voltage, or the deviation from Ohm's law, is shown in Figure 2. It will be observed that the resistance is maximum at approximately zero voltage. At a few tenths of a volt in the forward direction, the resistance falls very rapidly, tending towards a constant value as the forward voltage is increased. When the voltage is increased in the reverse direction, the resistance drops, but at a considerably smaller rate than in the forward direction.

Probably, the most interesting of all curves of the contact type rectifier is the volt-ampere curve known as the "static characteristic curve," Figure 3. In this curve the current, ma per sq cm, is plotted against positive d-c voltage for the forward direction and negative d-c voltage for the reverse direction. In order to show the reverse current axis on the same graph with the forward current axis, the former has been magnified 100 times. In the neighborhood of 0.3 volts, the forward current rises very rapidly. As the forward voltage is increased, the forward current tends to become linear. If we assume the electronic theory of rectification previously described as presenting a plausible explanation for the operation of the selenium rectifier, then as the accelerating potential increases, the number of free electrons passing through the barrier layer and reaching the supporting plate will increase very rapidly at first. As the applied voltage is increased, this rate diminishes, the couple finally acting in the same manner as a pure resistance. The curve shows that for equal voltages in opposite directions, the forward current may be several thousand times the reverse current. In practice, however, the reverse voltage is much larger than the forward voltage, so the current rectification ratio is usually of the order of 100 to 1. In the reverse direction, commonly referred to as the blocking direction, the maximum working voltage is usually 18 volts rms per plate, which corresponds to a peak voltage of about 25 volts. As has already been mentioned, selenium has a negative temperature coefficient. Before leaving this curve, therefore, it should be pointed out that as the temperature of the rectifier increases above room temperature,

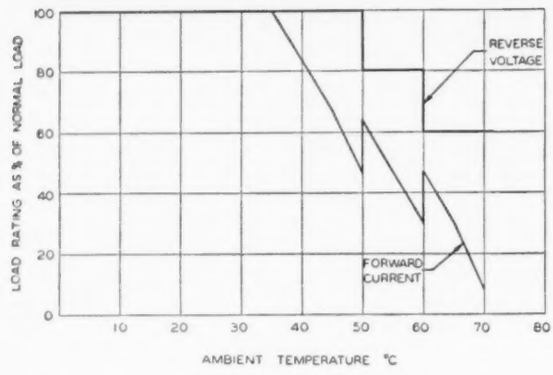


Figure 6 — Load rating vs ambient temperature.

the forward current curve shifts left towards the forward current axis.

The relationship between forward resistance and temperature of the selenium rectifier is depicted in Figure 4. The curve shows that for the normal working range of from 20 C (68 F) to 65 C (149 F), the variation of resistance with temperature is relatively small, being in the neighborhood of 22 per cent. Since the resistance of the rectifier is usually but a small portion of the total resistance of the connected circuit, the change in output due to temperature rise is unimportant.

The variation of reverse resistance with temperature is shown in Figure 5. It will be observed that the lowest resistance or maximum reverse current occurs at the lowest temperature, while for the 20 volt curve the maximum resistance value or minimum reverse current occurs at about 60 C (140 F).

The normal working temperature of the selenium rectifier is about 65-70 C or 140-158 F. The selenium rectifier is usually designed for an ambient of 35 C or 95 F; therefore, it has a considerable latitude in temperature range. The high operating temperature of the selenium rectifier permits its use in ambients below 75 C (167 F). However, for ambients in excess of 35 C, the power handled by the rectifier must be reduced to a value such that the temperature rise due to internal losses does not exceed the difference between 75 C and the ambient temperature. As the internal losses are the sum of the forward and reverse losses, both current and voltage ratings of the rectifier should be decreased. Figure 6 indicates the amount of derating for both blocking voltage and forward current for different ambients.

The normal current loading for selenium rectifying elements under natural cooling is 50 ma per sq cm, which corresponds to a potential drop of about one volt in the conducting direction. The voltage drop across a single plate in the forward direction may increase 50 per cent or more during the first 10,000 hours of operation. On account of this increase in the forward resistance of the selenium rectifier, it is necessary to increase the a-c voltage input to the rectifier 5-7 per cent after the rectifier has aged in order to maintain the d-c output voltage constant.

The current handling capacity of the selenium rectifier is a function of temperature rise and voltage breakdown. Peak breakdown voltage is about 40 volts in air. All our commercial rectifiers are engineered for a voltage well below this value and one which allows for a considerable variation in supply line voltage and aging. Breakdown is not the controlling factor, however, because we operate the rectifiers well below the maximum allowable voltage. The real limiting factor is the reverse current losses resulting in a temperature rise of the individual rectifying elements. It is only necessary to keep the impressed a-c voltage per element in the neighborhood of 14 to 18 volts rms to hold the reverse losses at a minimum. So long as the heat generated, due to the internal losses of the rectifier, can be removed fast enough to keep the operating temperature below 75 C, there is no practical limit to the amount of current that a selenium rectifier will handle. However, for normal convection cooling, a current density of 50 ma per sq cm or 323 ma per sq in. is usually employed. We frequently exceed this current density from two to five times by employing one of the following artificial cooling methods:

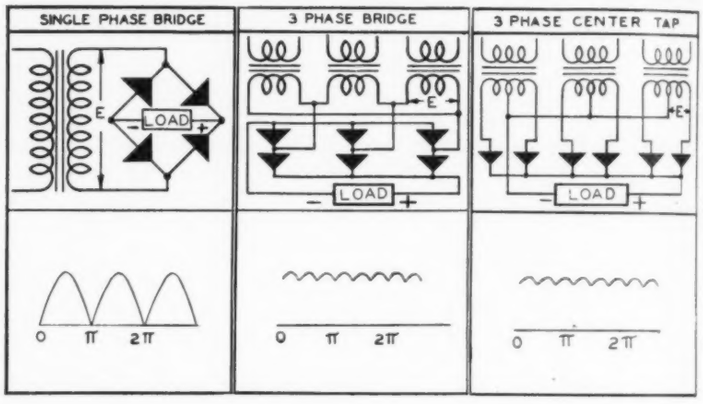


Figure 7 — (left) Single phase bridge.

Figure 8 — (center) Three phase bridge.

Figure 9 — (right) Three phase center tap.

1. Forced draft cooling through the use of a motor-driven fan.
2. Chimney cooling where the rectifier assembly is placed in a chimney-like enclosure without a fan.
3. Operation under oil with or without forced cooling.

It should be borne in mind that as the current density is increased, the forward voltage drop also increases, so that there is a practical limit beyond which it is not economical to go.

Having traced the history of the selenium rectifier briefly and having described the fundamentals of its operating mechanism, let us now consider the rectifier from the design and application view-point. By the mechanism already described, the metal plate rectifier converts a-c electricity into d-c pulsating electricity. Each time the sprayed metal layer is made negative with respect to the supporting plate, a large current flows from the supporting plate to the sprayed layer.

When a commercial a-c of say 60 cycles is applied to the rectifier, during 60 half cycles the rectifier is conducting and during the other 60 half cycles, it is blocking. The commercial a-c voltages available are rarely of the proper value to be converted directly into d-c. Therefore, a transformer is usually found associated with the rectifier. There are more than a dozen rectifier-transformer circuit combinations, but this discussion will be confined to the three most used circuits. The most common and widely used circuit is the so-called "single phase, bridge rectifier." Figure 7 shows this combination This type of rectifier circuit imposes a 120 cycle ripple on the d-c output which amounts to 48 per cent. The next most commonly employed combination is the three phase bridge. Again, this is a full wave circuit and Figure 8 shows the circuit and rectified wave form. The use of this circuit superimposes a 360 cycle a-c ripple on the d-c output amounting to 4 per cent. Both of these circuits make the fullest use of the exceptionally high blocking voltage characteristic of the selenium rectifier. Each single selenium plate will safely and continuously block 18 volts rms; therefore, in order to rectify 110 volts a-c, a minimum of 6 plates in series per arm of the bridge is required. Plating applications, as a rule, call for low voltages, usually between 3 and 16 volts. These d-c voltages are produced by employing but one selenium rectifying plate per arm of the bridge, the number of plates in parallel per arm depending upon the d-c current to be delivered by the rectifier.

The last circuit combination to be described is the three phase center tap circuit which makes the most efficient use of the high blocking voltage characteristics of the selenium rectifier in applications calling for an output of 9 volts d-c or less. Figure 9 depicts the circuit and the resulting wave form of the d-c output. This circuit, like the three phase bridge circuit, produces a 360 cycle ripple of 4 per cent magnitude.

The ordinary commercial selenium rectifier consists of an assembly of rectifying plates in the form of circular discs mounted on an insulated bolt. Figure 10 shows a typical rectifier stack assembly of this type. The stack assembly is admirably suited for low current rectifiers, say for 100 amperes or less. For d-c supplies of thousands of amperes as required in electroplating, this type of assembly has several shortcomings. The largest disc

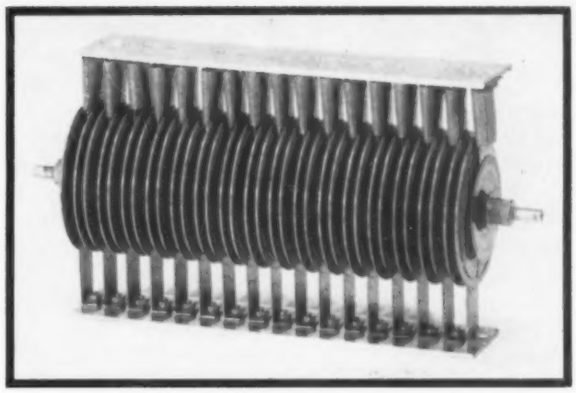
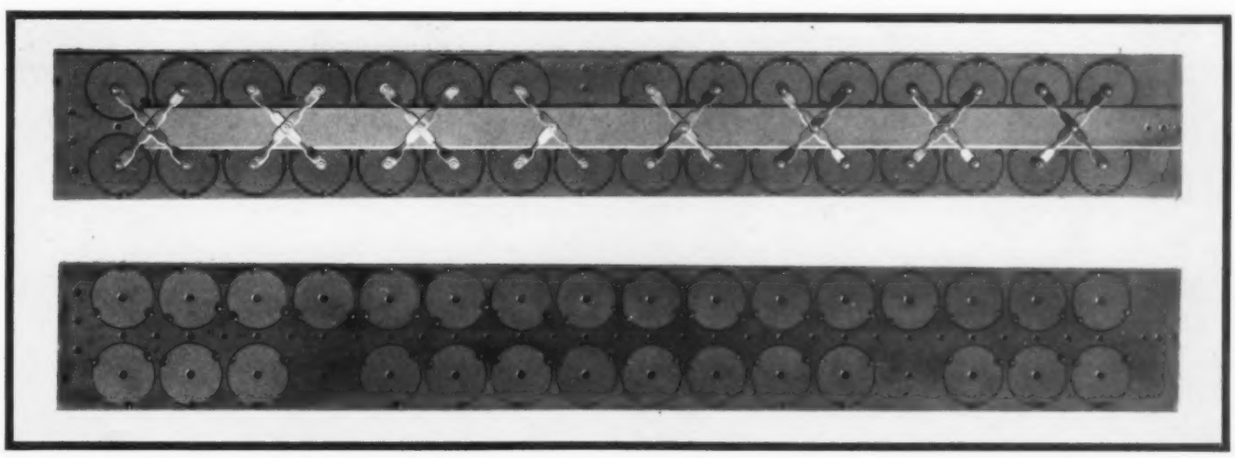


Figure 10 — Typical rectifier stack assembly.

produced at the present time is 4⅜ in. in diameter with a current capacity of 15 amperes when forced cooled and using a three phase bridge circuit. A bolt assembly of 22 of these plates comprises one arm of a three phase bridge rectifying 330 amperes. Such an assembly requires 23 lug connectors for the a-c and d-c connections. For an output of 1000 amperes, three such assemblies would be required consisting of 66 plates per arm and, as there are 6 arms to the bridge, a total of 414 individual lug connections besides the inter-bus connections between the lugs and between the 18 stacks. A d-c output of 10,000 amperes would require 180 such stacks with 4,140 individual lug connections and the associated inter-bus connections — a really staggering number of connections.

To simplify the construction and assembly of parallel plate assemblies, we have developed a new design of rectifier in the form of a strip or plate-type structure. Figure 11 shows the new simplified construction, which is a radical departure from the conventional stack assembly. Basically, the strip unit consists of a strip of steel, cadmium plated, of suitable cross-section to carry the combined currents of the individual rectifying elements attached to one side of the strip. Thirty-one selenium discs 4⅜ in. in diameter are spot welded to the supporting strip. Each disc is spot welded at three

Figure 11 — The new simplified rectifier strip assembly.



equi-distant points around its periphery. Figure 11 shows the strips with the discs spot welded to its surface. Figure 12 shows the spot welding set-up employed in the manufacture of this type of rectifier. The welds insure intimate electrical contact between the iron base plate of the selenium rectifying element and the supporting strip. Each disc's share of the total rectified current per strip is approximately 10 amperes; therefore, each weld carries about 3⅓ amperes. When the 31 discs are welded to the supporting strip, the latter becomes, in effect, an integrated rectifier with a current handling capacity of approximately 310 amperes. Spot welding the discs on the supporting strip reduces the number of individual lug connections by half and eliminates the inter-bus connections between lugs and between stacks.

The heat generated during rectification may be removed from the strips by any of the methods already mentioned. In electroplating applications where the rectifying elements are exposed to atmospheres laden with chemical vapors of many corrosive kinds, the strips are best protected by operation under transformer oil free from moisture and acids. A newly developed special contact with the sprayed metal layer front electrode is used, unaffected by oil seepage. Contact to the back electrode is taken care of by the spot welds. Therefore, oil seepage between the base plates and the supporting strip has no effect on the resistance.

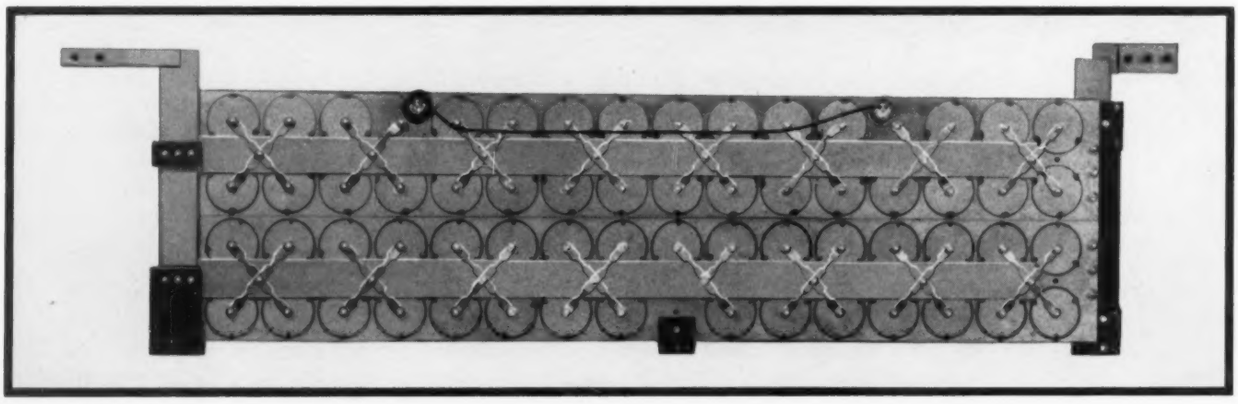
As was previously pointed out, the operating voltage of our selenium elements is so far below the breakdown point that breakdowns from over voltage are exceedingly rare, particularly when operating under oil. Another advantage to oil operation is the good thermal conductivity of the oil, which maintains a uniform temperature over the entire surface of each individual rectifying disc, making it possible to operate oil immersed rectifiers at somewhat higher impressed voltages than in air without increasing the reverse current loss heating effect.

For oil immersion, two supporting strips, each measuring 10 in. by 80 in., are mounted back to back with the rectifying elements facing outward. A ¼ in. space is maintained between the plates so that the oil has a chance to circulate between the inside surfaces of the neighboring plates. The a-c input to the discs on each pair of plates is by means of a copper bus, cadmium plated, carried on one of the plates, but insulated

Figure 12 — Spot welding operation in manufacture of rectifier.

therefrom. Heavy fuse links radiate from take-off points along the bus and feed the a-c to the sprayed layer side of the discs. Each link supplies a-c input to a pair of discs directly opposite each other on the supporting strips by means of insulated studs passing through the discs and holes in the supporting strips. Fusing of individual rectifying elements in parallel is an exclusive feature of this type of rectifier construction and adequately protects the disc. In case of breakdown, voltage or otherwise, between the sprayed layer and the base plate of a disc, the full energy of the a-c supply is impressed on the disc, immediately blowing the relatively heavy fuse for the normal current it has to carry, thus safeguarding the balance of the discs on the strips. We have been liberal with the number of discs in parallel to handle a given current so that 5-10 per cent of the discs could fail without putting the assembly out of commission. Two of the strip assemblies just described constitute a tank assembly for an oil immersed rectifier. Figure 13 shows the complete tank assembly out of the tank. The tank assembly consisting of four strips, each supporting 31 rectifying discs, has a current handling capacity of 1,250 amperes d-c at 12 volts. The tank is part of one arm of a three phase bridge, four such tanks constituting a full arm for a 5,000 ampere rectifier. Note that two thermal switches wired in series, and normally

Figure 13 — Strip type tank assembly.



closed, are mounted near the top edge of one of the strips. These switches are in a neon lamp circuit. Should enough of the discs in a tank fail, thus placing an excessive current load on the remaining operating discs, raising the oil temperature and, consequently, the discs' temperature above their top operating temperature of 75 C, a switch or switches will open, extinguishing the associated lamp, giving warning that a tank is running too hot and the cause should be investigated.

Figure 14 shows a tank with its assembly partly in the tank.

As already shown, the use of the strip-type assembly has reduced the number of individual connections by about 50 per cent of the number previously required and so represents a real advancement in the application of selenium rectifiers to large heavy current equipments. Also, this assembly permits the use of readily accessible fuse links, each of which serves one pair of selenium discs.

For applications such as electro-chemical plants and steel mills, which for many processes require large quantities of low voltage direct current, the problem facing any metal plate rectifier manufacturer is protection of the plates themselves. Varnishes and lacquers are being used satisfactorily under certain conditions; a humidified and filtered air supply is being used on some installations; and installations have been made with the rectifiers located in specially designed compartments away from the factory atmospheres. For the electrolytic tinning lines, it was felt that the available varnishes did not provide sufficient protection for long time operation; a special air system brought to each unit by ducts would be expensive and impractical because of the space requirements; and to locate the rectifiers remote from the load would require a large amount of copper bus which could be used to much better advantage in other locations.

It was decided then to take advantage of the ability of selenium rectifiers to operate immersed in a liquid, which would provide the necessary protection from corrosive fumes and other atmospheric conditions, and at the same time equalize any temperature differentials which might arise between the various sections of the plates themselves or between sections of the strip assembly. Immersion of selenium plates in a liquid had been practiced by Standard Telephones and Cables, Ltd., London, an I. T. & T. associate company, with especially fine results, and our own experience on several test models led to the conclusion that certain definite advantages were possible by this method of operation.

The cooling liquid in which the rectifier strips are immersed has been a point of controversy in several discussions recently. The units in operation in England were supplied with a good grade of transformer oil. The first experimental units built in this country were similarly equipped. Because of the objections to oil, even though the flash point is 275 F and the maximum allowable rectifier operating temperature is in the neighborhood of 175 F, investigations were started to locate a non-inflammable liquid, but up to present time, a more satisfactory material has not been found. The physical construction of the rectifier plate apparently makes the action of the selenium on the liquid, and vice versa, very slow, and extended tests will be necessary before a new material will be proven satisfactory. Incidentally, pyranol has been investigated and the action between the selenium and this material does not permit its use. The largest tanks built to date for the heavy current applications require 17.5 gallons of liquid per tank, and each tank is equipped with a liquid level indicating device and a drain plug.

As previously shown, the rectifier strip assemblies are mounted in very narrow tanks. These tanks are spaced 1¼ in. apart, and provide a very large surface from which the heat may be removed. Actually, with this construction, the surface area of the 36 tanks for the 7500 ampere, 12 volt unit is eight times that which it would be if a single tank were used.

When a new development is undertaken, such as large rectifiers for electrolytic tinning lines, there has to be some starting point for dimensions of the units, and, as is quite often the case, the customer's space limitations are the determining factors. The rectifier

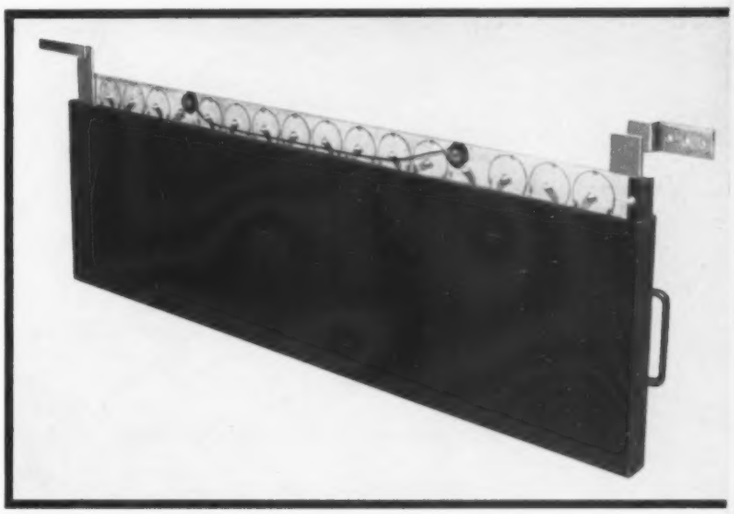


Figure 14 — Strip assembly partially inside tank.

units which we have built were designed in this manner, with definite limitations on width and height, and the further restriction that the units would be accessible only from the front or rear. Because of these limits, the rectifiers do not necessarily represent the most desirable or advantageous layout from the standpoint of floor space economy. Three sizes of 12 volt rectifiers have been built: 3000 amperes, 5000 amperes and 7500 amperes, and also a 5000 ampere, 9 volt unit. Figure 15 shows a 5000 ampere, 12 volt unit. The general layout of all sizes is the same, using strips and tanks of the same dimensions for interchangeability, the same length of subbase, cubicle, and transformer frame. The principle difference is in the width of the units, which is determined by the number of tanks required in parallel per arm of the three phase bridge circuit. The 3000 ampere unit has 18 tanks, or 3 in parallel; the 5000 ampere unit has 24 tanks, or 4 in parallel, while the 7500 ampere unit has 36 tanks or 6 in parallel per arm of the bridge circuit. The tanks are arranged in three tiers and are enclosed in a suitable cubicle. Figure 16 is a front view of the 7500 ampere unit with front doors

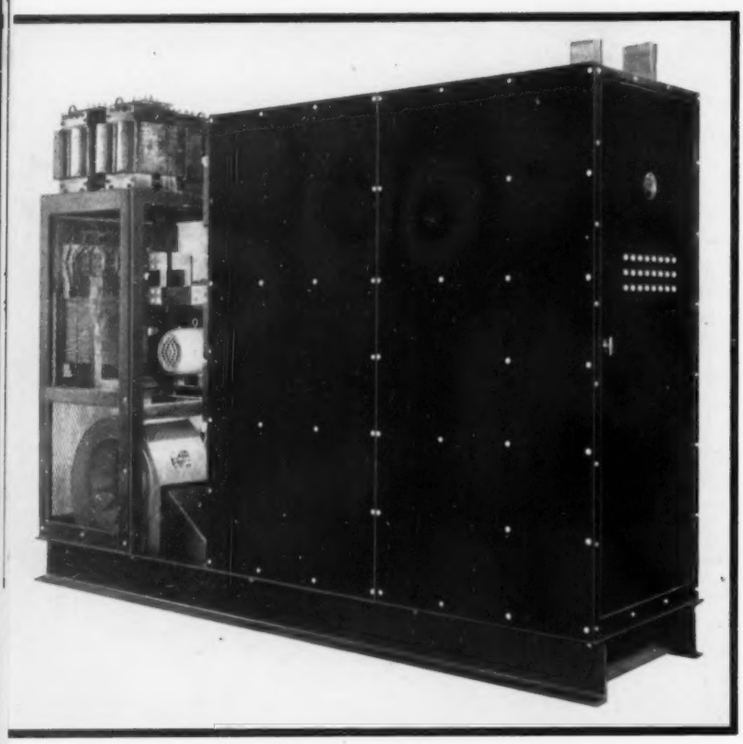


Figure 15 — (top) Selenium rectifier for 5000 amperes, 12 volts.

▲

Figure 16 — (bottom left) Tank and d-c bus assembly of 7500 ampere, 12 volt rectifier.

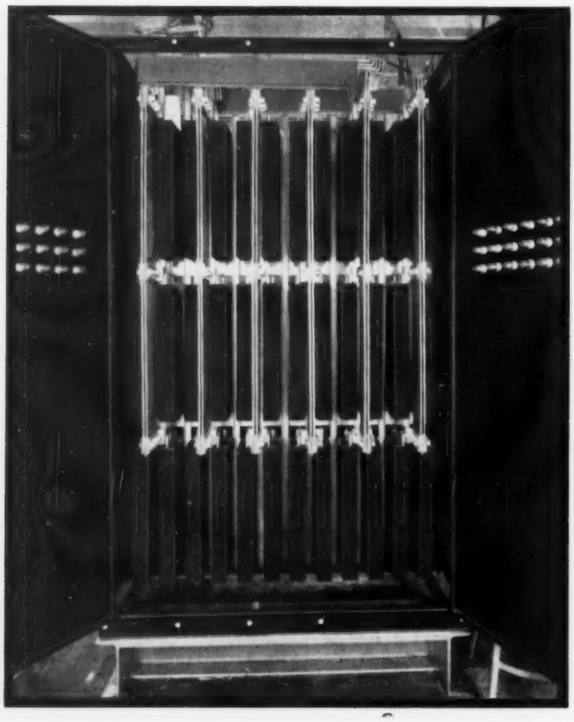
▲

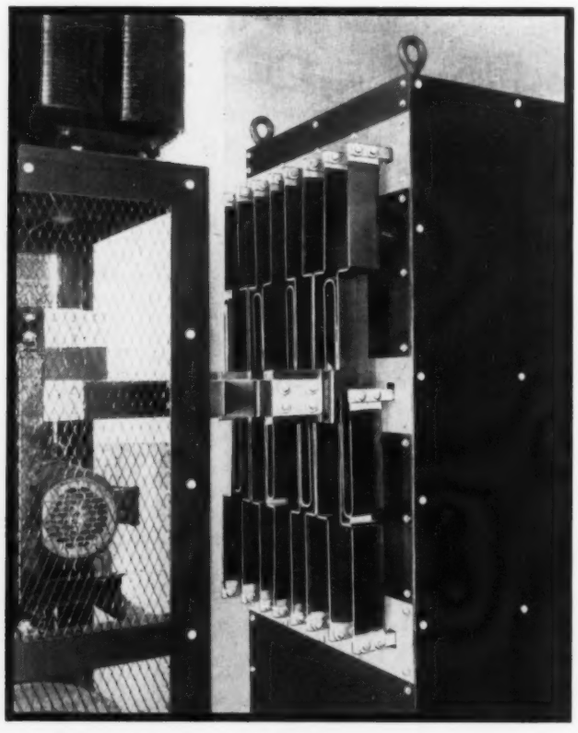
Figure 17 — (bottom right) A-c distributing bus of 5000 ampere, 12 volt rectifier.

open, showing the 36 tanks installed and the d-c buses rising between the rectifier leads. The chief advantage of this type of construction is the matter of inspection and servicing. Each tank may be withdrawn from the cubicle by unbolting the a-c and d-c leads, a matter of five bolts. As there are six tanks in parallel in each arm of the bridge, the unit may be operated with tanks disconnected or removed. With the unit type of construction, a long and expensive delay in operation is not necessary in the event that maintenance or servicing of one strip is required.

As shown in Figure 15, the tank cubicle is mounted on a sub-base, made of channels which act as an air duct and pressure equalizing chamber. A motor-driven blower is mounted to the rear of the rectifier tank cubicle, and sends air into this air duct which is then deflected upwards between the tanks, and discharged out the top. Because the rectifier plates are protected by being immersed, it is not necessary to filter or condition the air inlet to the blower, normal mill atmosphere being satisfactory. It is essential, however, that the blower size be based on the expected maximum ambient temperature to be encountered during operation.

The a-c supply to the rectifiers is brought in the back to the main power transformer which changes the high voltage a-c to low voltage a-c. Primary taps have been provided on the transformers to give three different secondary voltages, and taps are also brought out to enable operation on either 220 or 440 volt power systems. The secondary leads carry low voltage alternating current to the rectifier strip connections. In the rectifiers under discussion, the three-phase bridge circuit is used, the secondaries are Y connected and one rectifying element only per arm is required to deliver 12 volts d-c. It is essential that each tank have the same potential applied to it, in order that equal current distribution between tanks in parallel may be maintained. As





variations in the length of bus bar leads are sufficient to upset the balance between tanks, we designed a special a-c distribution bus structure in which the length of bus to each tank is the same length as every other bus (Figure 17).

In order to vary the d-c output voltage of a rectifier, there are several methods in general use. Among these are the use of induction regulators, taps on the main transformer primary circuit connected to tap switches, tapped auto-transformers with tap switches, and saturable core reactors. The object in all cases is to raise and lower the a-c voltage to the rectifier which directly affects the d-c output voltage. The type of control to be used is entirely dependent on economics and the requirements of the application. For this application, the saturable core reactor type was used because it provides a smooth control from three-quarters of a volt up to 12 volts. The number of steps of control is determined by the number of steps on the rheostat in the reactor d-c circuit. The reactors are built as three single-phase units with the a-c winding in series with the line, and placed ahead of the main transformer. A d-c winding is also placed on the same core. As the current in this reactor d-c winding is increased, the a-c voltage on the main transformer primary is increased, raising the d-c output voltage. Provision has been made for mounting of the reactors above the main transformer as shown in Figure 15. Both the transformer and the reactors were designed for normal convection cooling, and they were built with class B insulation.

As previously described, each rectifier tank assembly has two thermostatic switches mounted at the top of the strip. These may be connected as desired, but for the units being described, indicating lights on the equipment doors were used. These lights are numbered to correspond to the tank numbers, and are equipped with neon glow lamps, normally on. The thermostat switches (normally closed type) were connected in series so that trouble, as evidenced by overheating and opening of either switch, would be indicated by an extinguished light. A small single-phase, 220/110 or 440/110 volt, transformer supplies power for these lamps. A two pronged plug and socket is provided for each tank cover, so the tanks may be readily removed and replaced without disturbing the wiring of the signal system.

The blower motors are electrically interlocked with the main rectifier contactor so that the unit may not be operated without the blower. No other relays have been included as it was felt that the light system was sufficient indication of trouble. Also, the failure of a single tank would in all probability never noticeably affect the temperature of the exhausted cooling air, at least not sufficiently to insure operation of the usual protective devices, as the normal temperature differential between inlet and outlet air is 10 C on the 7500 ampere units. Likewise, it was felt that the failure of one tank should not require throwing the complete unit off the line.

To give some idea of the magnitude of the job, it should be pointed out that up until the electrolytic tin program got under way, the largest single rectifier built by the company was rated 40 kw. The 7500 ampere units described are rated 90 kw each, making a total of 1973 kw being supplied for this tinning program. Up to the present time, we believe this 90 kw unit is the largest single unit, metal plate rectifier in the world.

In order to produce the rectifiers totaling 1973 kw capacity, a large quantity of material was required, including the following:

Over 95,000 selenium rectifier discs
Over 30 tons of copper bus bars
Approximately 120 tons of steel
Over 14,000 gallons of transformer oil
Over 75,000 cap screws and nuts
Over 250,000 washers.

The overall dimensions of these 12 volt units are as follows:

Ampere	Width ft-in.	Height ft-in.	Depth ft-in.
7500	4-8	8-4	12-6
5000	3-3	8-4	12-6
3000	2-7	8-4	12-6

To permit interchangeability of all tanks and strips, the same height and depth dimensions were used on all units, varying only the width.

In conclusion, we feel that this new form of selenium rectifier will be applicable to an increasingly large number of applications requiring high current, low voltage, direct current power. Because of the low maintenance, and the fact that only one rectifier element is required for voltages up to 12 volts at present, and they may be immersed in a protective liquid, we believe that selenium rectifiers are particularly advantageous for steel mill installations.

DISCUSSION

PRESENTED BY

I. R. SMITH, Rectifier Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

H. W. POOLE, Steel Mill Section, Industrial Engineering Division, General Electric Company, Schenectady, New York

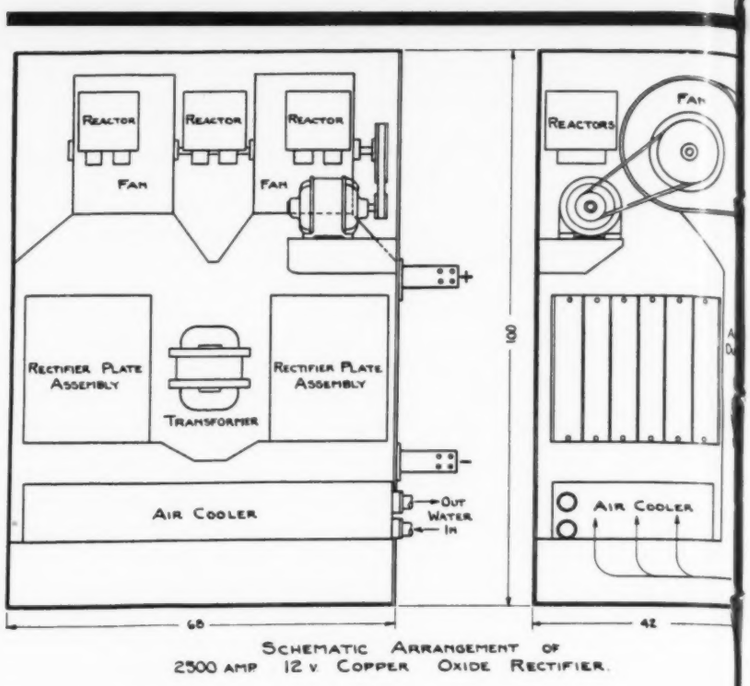
I. R. SMITH: In the field of metal rectifiers, the selenium and copper-oxide types are predominant. In this country the copper-oxide rectifier has been known for many years, and has found its way into every conceivable type of application. So it is only natural that a number of the continuous tinplating lines now going into operation should have been powered by the copper-oxide type of rectifying unit. It may be of interest to see what the construction of the oxide rectifier is for this application.

Instead of building an oil-immersed unit, which sometimes involves limitations as to installation conditions, we have employed the standard fan-cooled type of construction, but have enclosed all the parts of the

rectifier in a totally enclosed cabinet, within which the ventilating air is recirculated by a blower. The losses generated by the rectox units and their associated parts are then removed by cooling water, through the medium of a heat exchanger. Such a unit then, runs into no restrictions as to installation, and can be set down to operate wherever it is most convenient.

The type of design is shown in Figure 1. Ventilating air is forced by the blower down through an air duct along one side of the cabinet, up through the heat exchanger then through the rectifier units and the power transformer, past the saturable reactors, and back into the blower again. The transformer is built with two separate secondaries, and the rectifier units as shown are in two separate blocks. Each of these is good for 6 volts, 2500 amperes. The output buses are brought out separately at one end, where they can be paralleled to give 6 volts, 5000 amperes, or connected in series to give 12 volts, 2500 amperes. No other changes are necessary to accomplish this.

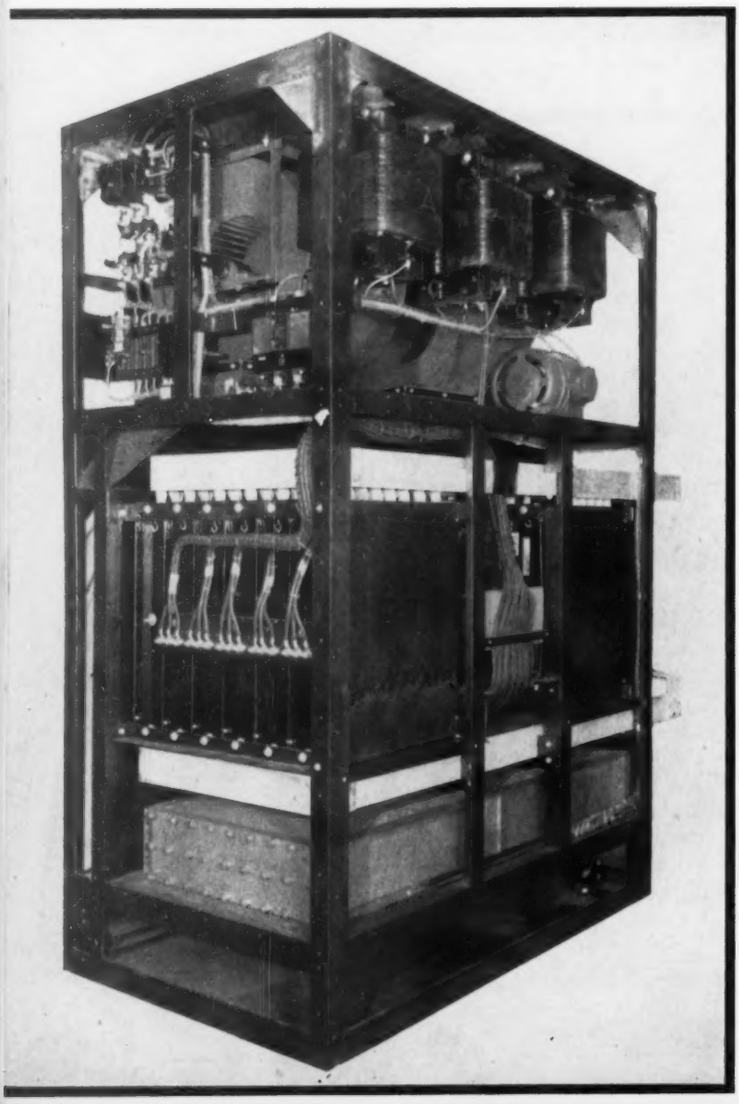
Control of the output over a range of more than 10 to 1 in both voltage and current, or over 100 to 1 in w tts, is obtained by means of the saturable reactors which are in the primary circuit of the transformer. These reactors are excited from a d-c bus which is



Schematic Arrangement of 2500 amp 12 v Copper Oxide Rectifier.

Figure 1 — Diagrammatic view of totally enclosed type copper oxide rectifier.

Figure 2 — Front view of copper oxide rectifier with panels removed.



common to all the rectifiers. Hence they can all be controlled in unison by varying the bus voltage, or any one rectifier can be adjusted independently of the others by means of a manually operated rheostat on the control desk. Thus the operator can increase the voltage on any set of electrodes as they wear away, maintaining full current, while the output of the entire group of rectifiers can be controlled to match the line speed as it is brought down to minimum for welding on the next roll of strip.

The main breaker disconnect is operable from outside the unit, so that any unit can be cut off when it is necessary for it to be worked on, without interrupting the other units. Reset buttons for the main a-c contactor and the blower motor contactor are also accessible from outside. Cleanout of the heat exchanger is accomplished by removing the front panel, which then exposes the head of the exchanger. This complete unit weighs 6860 pounds, stands 100 inches high, and is 42 inches wide by 68 inches deep.

At the other end of the rectifier are brought out the two sets of 6 volt, 2500 ampere buses, which may be connected in series for 12 volt operation. Also at this end are the external connections for the water supply to the heat exchanger through which a flow of 15 gallons per minute is to be maintained.

Figure 2 shows the internal construction of the rectifier, which is simple and rugged, giving a view of the front end, and one can clearly see the two blocks of plates, as well as the heat exchanger (cleanout end), the saturable reactors, breakers and magnetic contactors.

In order to conserve floor space, the rectifier frame has been designed to be strong enough so that one rectifier may be mounted directly on top of another one, if desired.

Two sets of efficiency curves are included to give a picture of the performance of the rectifier. It should be noted that these differ in shape from the usual efficiency curve, which is taken at constant output voltage and for different values of load current. In the tin plating line, such conditions do not represent the normal service.

Starting with a new set of anodes the rectifier output will be set at the desired current, usually full load, and whatever voltage is required to produce this current. This voltage must of necessity be less than the full rating of the unit so that as the anodes wear away, current can be maintained at the right value by increasing the voltage. This the operator does on each rectifier as needed, by adjusting the rheostat in the reactor control circuit.

Figure 3 then shows how the efficiency varies as the load voltage is changed from 6 to 12, the current being held constant at full 2500 amperes.

Another condition which exists is that of slowing down the plating line from full speed to 10 per cent or less for the purpose of welding on a new roll of strip. When this is done, the plating current is reduced likewise. Since for the moment the load resistance is fixed, both current and voltage come down together. The efficiency existing during this operation is shown in Figure 4.

In connection with these two curves, it should be noted that the tests were made at rather low air temperatures. At higher temperatures some improvement in efficiency is to be expected.

The use of metal rectifiers for such large blocks of power is a new development in this country, although individual units of comparable size to this one have been in successful use for several years. Naturally, the performance of these rectifier operated lines will be followed with close interest by steel mill and plating engineers. We believe there is no doubt that the successful performance of these lines will mean greatly increased use of metal rectifiers by the steel industry in the future.

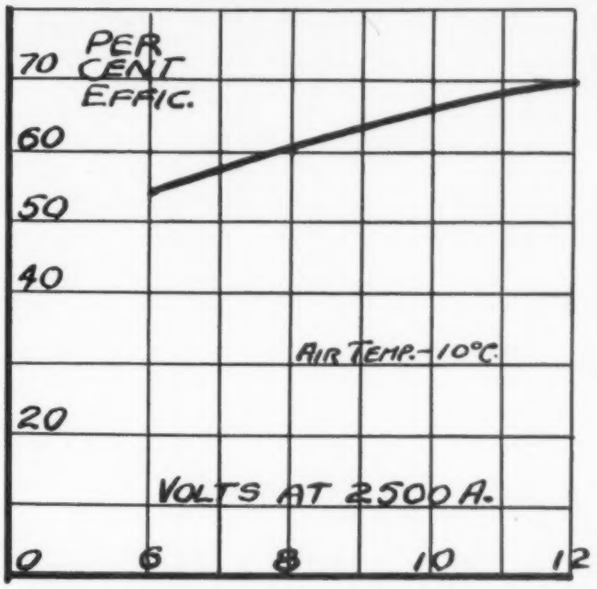
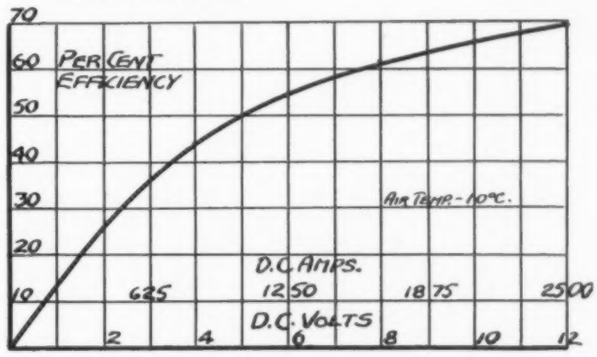


Figure 3 — Overall efficiency, 12 volt, 2500 amp copper oxide rectifier at 6 to 12 volts, with 2500 amp load.

Figure 4 — Overall efficiency, 12 volt, 2500 amp rectifier on fixed resistance load.

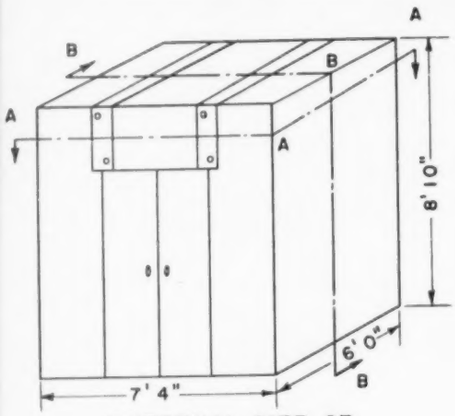


H. W. POOLE: Something over a year ago the first steel mill application of dry-plate rectifiers for continuous electrolytic tinplating was initiated by our company, and has been successfully operating in the Chicago district.

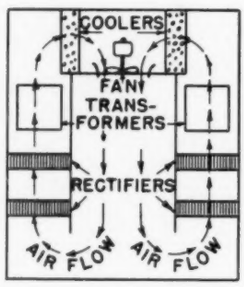
Figure A is a sketch showing a 5000 ampere, 9 volt copper-oxide rectifier for electroplating. The transformers, rectifier units, surface air coolers, and fans are contained in a common steel enclosure. Physically, the transformers and rectifier units are divided into four groups each of which has a rating of 1250 amperes at 9 volts or a combined rating in parallel of 5000 amperes at 9 volts. Two banks of coolers and two fans serve to ventilate the four groups of rectifiers and transformers within the single enclosure.

An important feature of this construction is the complete access to the electrical parts of the unit by entering the double doors in the center of the unit and taking off the cover plates inside. There is ample room for a man to stand and work inside the unit and each of the four sections can be isolated electrically as well as mechanically so that a man can work on one 1250 ampere section without disturbing the other three sections. The fact that no access is required to the sides and back of the unit allows placing the several units required for a given line back to back and side by side without intervening aisle space. In the case of one type of continuous tinplating line where 60,000 amperes at 9 volts is required, the overall length of the rectifiers required is approximately the same as the plating tank. The units are arranged in two rows back and side by side with very little space in between. Such an installation is shown in Figure B where the rectifiers are mounted on a balcony over the control. Mounting the units in this manner requires the minimum of floor space and allows direct and short runs to the plating tanks.

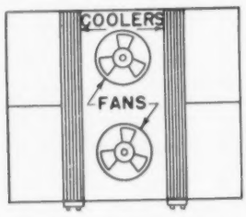
In Figure C are the fundamental transformer connections which we use in building copper-oxide rectifiers for high-current, low voltage installations. The basic connections shown are for 6 volt and 9 volt service, and 12 volts can be obtained by placing two 6 volt banks in series.



EXTERNAL SIZE OF
5000 AMP. 9 VOLT RECTIFIER



SECTION B-B-B



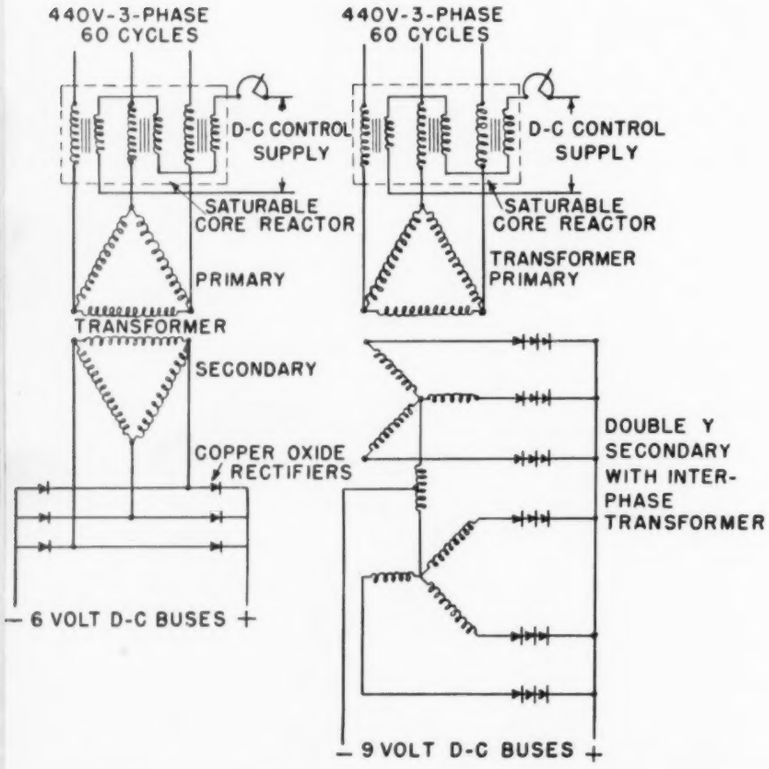
SECTION A-A-A

SKETCHES SHOWING GENERAL ARRANGEMENT OF 45 KW, 5000 AMP. 9 VOLT, RECTIFIER UNIT WITH SURFACE WATER COOLERS AND RECIRCULATING VENTILATION.
NOTE: THIS RECTIFIER CAN ALSO BE FURNISHED WITH RATINGS OF 8000 AMP. AT 6 V, 4000 AMP. AT 12 V, 3000 AMP. AT 15 V, OR 2500 AMP. AT 18 V.

Figure A

▲

Figure B



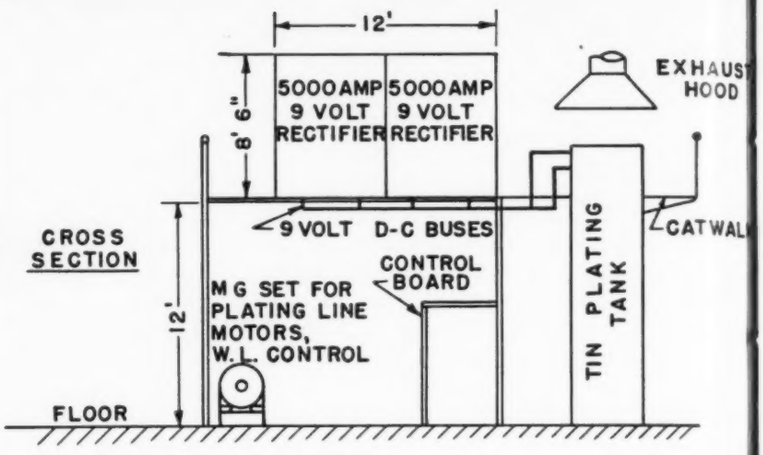
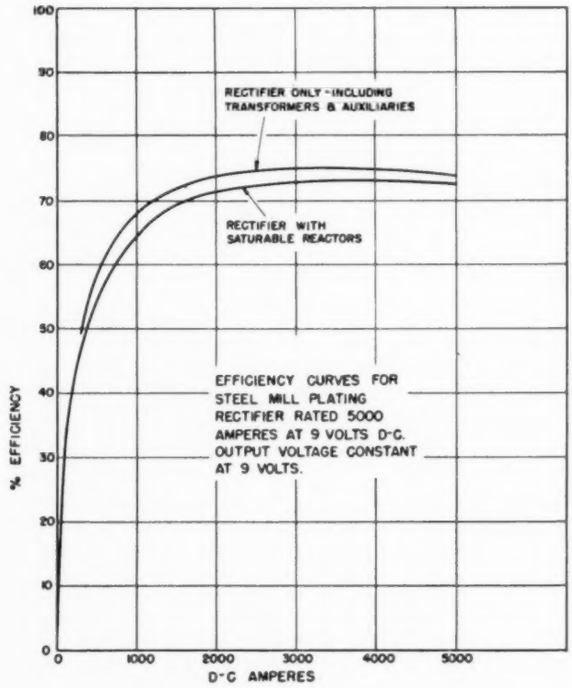


Figure C

As a means of controlling the output voltage of the rectifiers, saturable core reactors can be used as shown in Figure C. The a-c winding of the reactor is in series with the primary of the rectifier transformer. The d-c winding of the reactor is connected to a d-c source and may be adjusted by a rheostat or by varying the source of d-c voltage as with an exciter. Increasing the current in the d-c winding of the reactor increases the output voltage of the rectifier and vice versa.

The efficiency curves shown in Figure D are plotted from test data taken on a 5000 ampere, 9 volt unit made for steel mill electroplating service. Inasmuch as these tests were made on a new unit, the efficiencies are somewhat higher than the guaranteed values which are

Figure D



obtainable after the rectifier has "aged." It should be pointed out here that these tests were made by holding the d-c output voltage constant and varying the load resistance. Similar curves obtained by holding a constant load resistance and varying the output d-c voltage will have a different shape and will drop off more rapidly from full load to no load.

It is gratifying to see the interest evidenced in the application of dry-plate rectifiers for steel mill service and I feel sure that many new applications will be made in the future. In the meantime, installations that are now being made will provide much valuable data for future reference.

SMITH *Discussion*

(*Continued from page 65*)

H. E. PHELPS: Assuming that a pit would hold twelve ingots, rolling an ingot every three minutes, about how much drop in temperature would you anticipate between them?

E. G. SMITH: Assuming a pit holding 12 ingots 24 in. x 24 in. and rolling ingots at the rate of one every three minutes, there would not be any perceptible temperature drop between the first and last ingot drawn.

M. R. SCOTT: Assuming you were rolling an ingot every three minutes, would there be any appreciable difference in soaking time of the ingots in the center of the pit and those at the back? In other words, those located close to the nozzle injector?

E. G. SMITH: Ingots are grouped around the central burner in a single row and with furnace pressure control, ingots are practically all the same temperature.

P. M. OFFILL: I would like to say for the record that we are definitely able to maintain temperatures in the pits during the drawing operation. Continuous records of furnace temperatures which are available to anyone of you will show that we do not lose any temperature during the drawing cycle for the following reasons: automatic and rapid resumption of firing the moment the cover is seated, and of course the cover seal; thoroughly insulated pit walls, bottom, and cover, plus the fact that our recuperator stores enough heat so that our preheated air temperature does not drop during the cycle; all of these contribute to the maintenance of temperature during the drawing cycle.

H. C. HOEFT: It is known that a crane has dropped ingots already. What protection do you have for this, in case an ingot is dropped?

P. M. OFFILL: This is a problem we faced in our early days and in our negotiations prior to the sale of our first few installations, we had plenty of trouble getting over this particular hurdle. However, we soon worked this out by insisting that the crane operators must not carry the ingot over the firing port, just as they do not carry an ingot over the cover carriage.

In one plant we offered the ingot crane operators a suit of clothes if they did not drop an ingot on the firing ports in 30 days — they did not drop an ingot and the mill management said "Don't you ever drop an ingot."

That increased care in handling ingots to and from any pits will pay handsome dividends is now generally recognized. It must also be conceded that good housekeeping which means proper maintenance and handling of equipment will be well worthwhile.

F. C. FRYE: I have a question. What is the cover life, moving the cover, picking it up with the crane, what is the average cover life?

P. M. OFFILL: We have used practically all suspended arches in our covers of first quality and superduty refractory. The latter being used almost exclusively during recent installations.

Obviously covers can be ruined by overfiring them by a burner out of adjustment or by improper care of sand seals which does not permit the cover to close tightly. However, 5 year life is not unusual with normal care.

In our earlier pit history the statement was made many times that vertical firing would burn out a cover in 30 days, but we have been able to demonstrate that with the proper burner positioning and positive furnace pressure control the covers give very satisfactory service.

L. R. MILBURN: Is it advisable to charge cold ingots as you take out hot ingots, or should you wait until you have completely emptied the pit before you put in a new charge?

P. M. OFFILL: I would say that it is normal practice to draw all the ingots in a pit before charging any ingots because of the cooling effect of the ingot to be charged.

There is another point in connection with the recuperator tube tile that should be mentioned here.

The tube tile are cast in a plaster of Paris mold that permits a material density and uniformity of body that is not obtainable in other processes.

The porosity of tile body is under 12 per cent which means increased thermal conductivity. The uniform disposition of the clay bodies in the tile walls produces a tile that stands severe thermal shock.

We would like to again suggest that you look at the temperature chart showing relative furnace temperature and air preheat. It will be noted that the preheated air temperature varies only slightly during the entire pit heating cycle.

W. E. REIBER: What mechanism is used for lifting covers?

E. G. SMITH: The cover crane we have designed and patented will lift a cover to clear by means of a motor driven hoist for each cover and a motor drive for a traverse movement of the cover. The cover carriages are built for spanning one, two or three pits and are so interlocked electrically that the traverse motor will not start until the cover lift is completed.

W. E. REIBER: Do you use hydraulic or gearing mechanism for lifting covers?

E. G. SMITH: Electrically driven hoists are used exclusively although a hydraulic hoist could be used.

W. E. REIBER: Does your operator ride the cover carriage?

E. G. SMITH: We have cab operated and remote control on the cover carriages, although the jobs that come through for more than one row usually specify cab control.

JAMES A. SMITH, JR.

J. H. MILLER

T. C. MAYBERRY

NEW DISTRICT CHAIRMEN, A. I. S. E.

C. H. Williams was graduated from the University of Colorado in 1926 and was employed by Jones and Laughlin Steel Corporation as shear foreman in their Pittsburgh plant. In 1927 he became a junior engineer in the power department of National Tube Company at Pittsburgh, shifting in 1930 to the Ohio Works of Carnegie Steel Company. Here he served successively as junior engineer, power and fuel engineer, and assistant chief engineer. In 1940 Mr. Williams was transferred to the Pittsburgh office of Carnegie-Illinois Steel Corporation as power and fuel engineer on the staff of the chief engineer, and was subsequently appointed assistant chief engineer of the Pittsburgh district. In 1941 he was placed in charge of a newly organized defense engineering staff to coordinate the engineering of defense steel plant expansions of the company in the Pittsburgh district. He was subsequently transferred to the United States Steel Corporation of Delaware as assistant to the vice-president of engineering, and in 1943 to chief engineer of the Pittsburgh district, Carnegie-Illinois Steel Corporation.

James A. Smith, Jr., is a native of Birmingham, Alabama, and a graduate of V. M. I. and Cornell University. For the past six years he has been associated with the United States Steel Corporation in the Pittsburgh and Birmingham districts. He is now employed as assistant superintendent of shops, Fairfield Steel Works, Tennessee Coal, Iron and Railroad Company.

Stanley Grand-Girard was born at Circleville, Ohio, in 1890, graduating from Everts High School in 1908, and from Purdue University in 1912. He started with the Youngstown Sheet and Tube Company as inspector helper, advancing to the position of general electrical foreman of the coke plant. In 1917 he joined Republic Iron and Steel Company as assistant electrical engineer, remaining there until 1928, when he went with Sharon Steel Corporation.

J. H. Miller worked for the Georgia Power Company from 1922 to 1929 in various capacities, from cooperative student to substation testing, obtaining a B.S. degree from Georgia Tech in 1927.

He then entered the test course of the General Electric Company at Schenectady and was transferred to the St. Louis service shop of that company in 1930. In 1935, he went to the Wisconsin Steel Works of the International Harvester Company as electrical draftsman, advancing to the position of assistant electrical superintendent in 1936, and electrical superintendent in 1939.

F. C. Schoen was born in Cleveland, Ohio, in 1907, and in 1930 received a B.S. degree in Electrical Engineering from the Case School of Applied Science.

He was then employed by the General Electric Company, Fort Wayne, Indiana as a student engineer, moving in 1933 to Republic Steel Corporation, Massillon, Ohio, as a motor inspector and advancing to the position of electrical maintenance foreman.

In 1938, he transferred to the Midvale Company, Philadelphia, as an assistant to the plant engineeer, later being made master mechanic. In 1943, Mr. Schoen was given an M.S. degree in mechanical engineering from Towne Scientific School of University of Pennsylvania.

T. C. Mayberry began his career in 1920 in the cold strip department of the Greer Steel Company at Dover, Ohio, as a helper on the cold reducing tandem mill. In 1921 he went to Trumbull Steel Company, Warren, Ohio, where he worked as helper, roller, and turn foreman until early 1931. He then went to Wheeling Steel Company as general foreman of the cold reducing sheet mill department. In January, 1934 he was employed as superintendent of the cold reducing tinplate department of the Youngstown Sheet and Tube Company, Indiana Harbor Plant, being transferred in 1935 to the Youngstown, Ohio, Plant, as assistant superintendent of the cold reducing sheet mill. He next went to Great Lakes Steel Corporation in 1936 as superintendent of the cold reducing sheet mill. In 1940 he was appointed assistant general superintendent of the Great Lakes Steel Corporation, and in 1941 he was promoted to his present position as general superintendent.

F. C. SCHOEN

STANLEY GRAND-GIRARD

C. H. WILLIAMS

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You get two distinct advantages in every Birdsboro "Curoloy" Grain Roll. First, there's the patented analysis that assures finer finishes and longer roll life. Second, there's the fact that every one is SPECIALLY made to meet the individual requirements of the job it must perform. And the two add up to finer roll performance, greater mill production. If YOURS is a roll problem, it pays to consult Birdsboro!

● "Curoloy" is the Birdsboro patented grain roll for roughing, semi-finishing and finishing of mild alloy and special steels, non-corrosive irons and steels, non-ferrous metal bars and shapes at low and high temperatures. Available in four grades—hard, medium, mild and extra mild to meet your specific needs. The 19" x 36" rolls shown being turned are used for cold rolling nickel silver and phosphor bronze.

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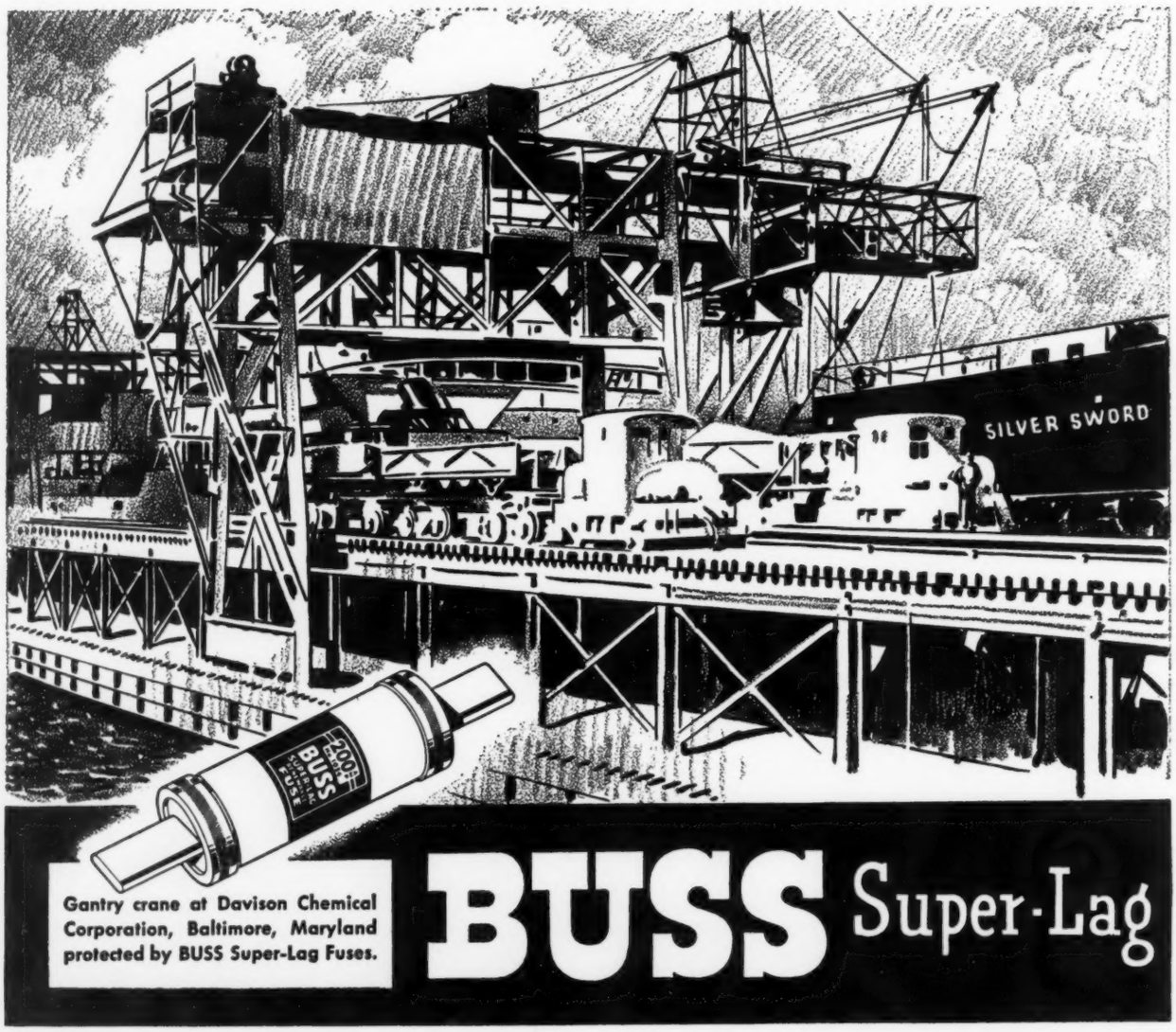
"We Got Rid of Costly Shutdowns

On Our Cranes—And Stopped Shorts From Burning Up Our Heavy Copper Trolley Wire, When We Replaced 600 Ampere Fuses With 400 Ampere BUSS Fuses."

Says **MR. STANLEY REISLER, Supt. of Elec. Dept.**
Davison Chemical Corp., Baltimore, Md.



Gantry crane at Davison Chemical Corporation, Baltimore, Maryland protected by BUSS Super-Lag Fuses.

BUSS Super-Lag

"The value of BUSS Super-Lag fuses is of greater importance today than ever before, because of the scarcity of copper trolley wire, and the need to make every minute, hour, and day count. We must keep the working crew, who depend on our cranes to handle material for them, on the job.

"We started to use 400 ampere BUSS Super-Lag fuses over 12 years ago, replacing 600 and 800 ampere fuses in the main feeders to our cranes.

"We found that BUSS fuses not only eliminated useless shutdowns, caused when a momentary overload occurred—but, when a trolley wire broke, the 400 ampere BUSS Super-Lag fuse blew instantly when the broken wire shorted on the others. There was hardly a mar on the other wires.

"Before swinging to BUSS, such shorts often burned out the entire set of wires, which had to be replaced—tying up our cranes for 3 or 4 days for this major repair job. We're certainly sold on BUSS Super-Lag fuses."

STANLEY REISLER, *Supt. of Elec. Dept.*
Davison Chemical Corp., Baltimore, Maryland

Are You Tolerating *Useless* Waste of Time and Material Because of Fuse Failures?

In Davison's plant—as in thousands of others—the long time-lag of BUSS fuses prevented them from opening on momentary or harmless overloads.

In an effort to prevent useless shutdowns with other fuses, Davison tried 600 to 800 ampere fuses. But even with these large size fuses they still had many needless blows. Protection was sacrificed to such an extent that on short-circuits trolley wires were frequently badly damaged before the fuses would blow.

400 Ampere BUSS Super-Lag fuses solved Davison's problem because they were able to withstand momentary surges, yet the smaller size opened instantly when there was real danger caused by a shorted wire.

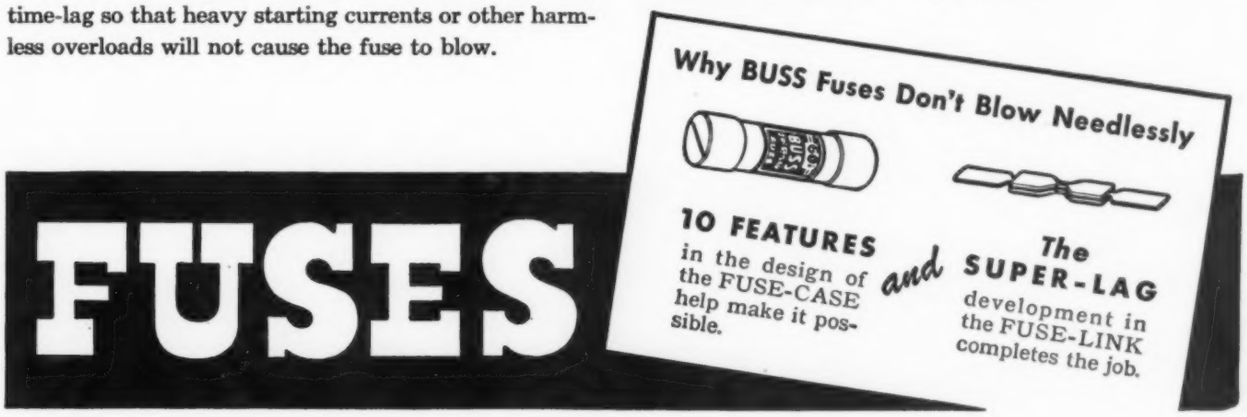
Here's Why BUSS Super-Lag Fuses Greatly Reduce or Entirely Prevent Needless Blows

The fuse case is designed to insure good contact on the link, even when the fuse is renewed by an inexperienced person—and it is so designed that vibration or heavy overloads or the constant heating and cooling of the fuse will not permit poor contact to develop. Thus, excessive heat which causes fuses to blow when they should not is prevented.

The fuse link used is the famous "BUSS SUPER-LAG." It has lag-plates attached which give it a long time-lag so that heavy starting currents or other harmless overloads will not cause the fuse to blow.

And Here Is How to Solve the "Shut-down Problem" in Your Own Plant

Be sure that all purchase records dealing with circuit protective devices call for BUSS Super-Lag Renewable fuses. Then, as fuses are replaced or new installations made, your plant will automatically get the benefit of the carefree, trouble-proof protection that BUSS Super-Lag fuses assure. BUSSMANN MANUFACTURING COMPANY, *Division McGraw Electric Company*, University at Jefferson, St. Louis, Missouri.


FUSES
Why BUSS Fuses Don't Blow Needlessly
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in the design of the FUSE-CASE help make it possible.
and
The SUPER-LAG
development in the FUSE-LINK completes the job.

We're producing rod at the rate of over 4,000 fpm with four Morgan Repeaters in this compact mill.

Two of them are 180° overfeed repeaters, and two are of the combination take-up and overfeed types, supplying two double-strand finishing trains.

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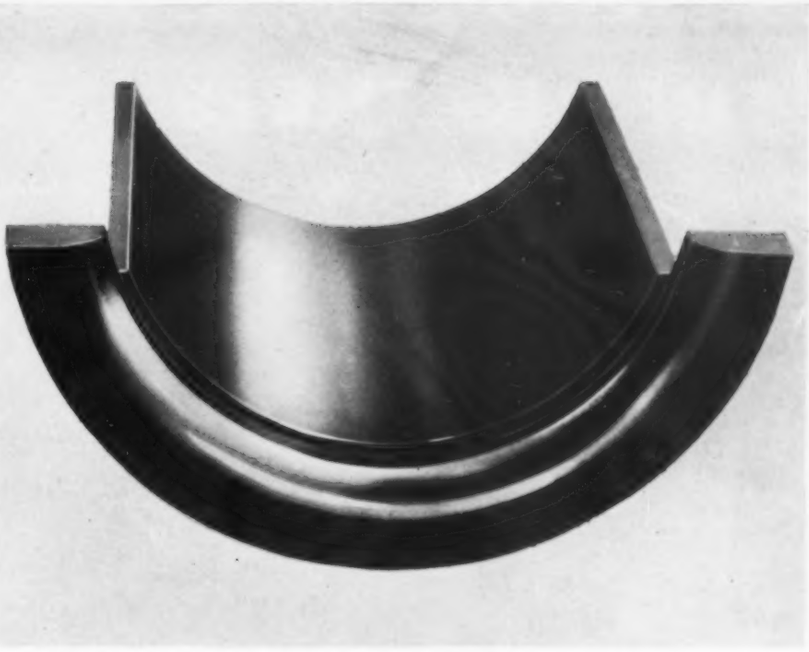

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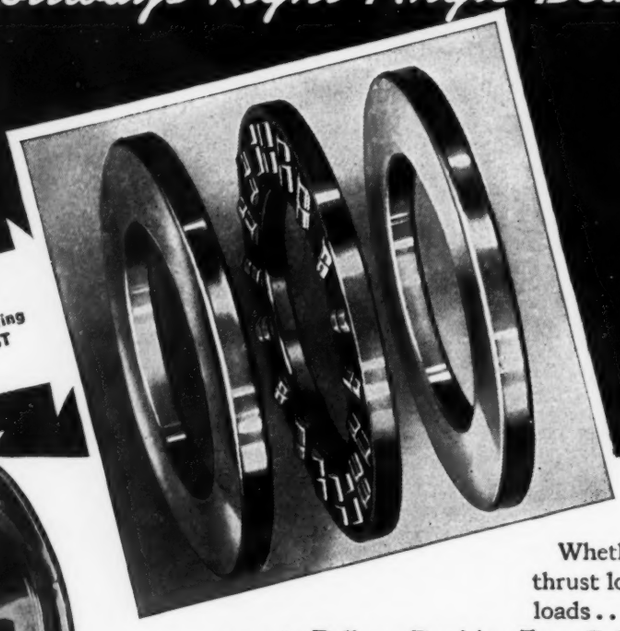

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For longer bearing life, more efficient performance and more economical maintenance . . .

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Simplification — that's the answer back of the increased capacity and life of Rollway's Cylindrical Roller Bearings. For Rollway splits every load into its two simple components of *pure radial* and *pure thrust—carrying each of these on separate bearing assemblies at right angles to the roller axis.* That eliminates compound loads, oblique loads, and the resultants of compound forces. The total magnitude of stress carried per roller and per bearing is substantially less. Rollers and races stand up longer. Lubrication is simplified. And the cylindrical rollers eliminate all tendency to pinch out between the races, greatly reducing end-rub and wear-back of the roller head.

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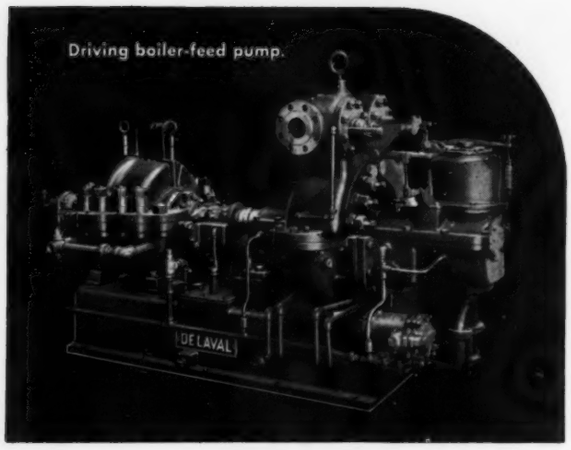
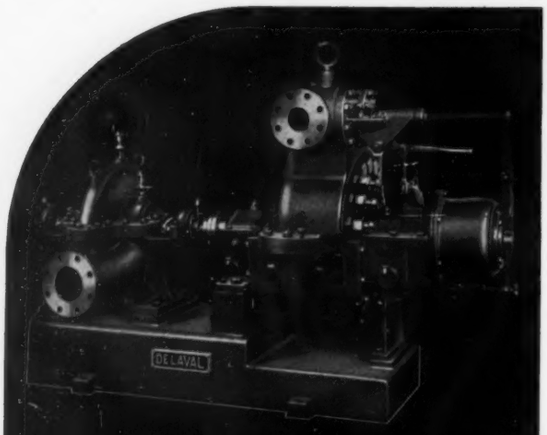
"Its the Film"

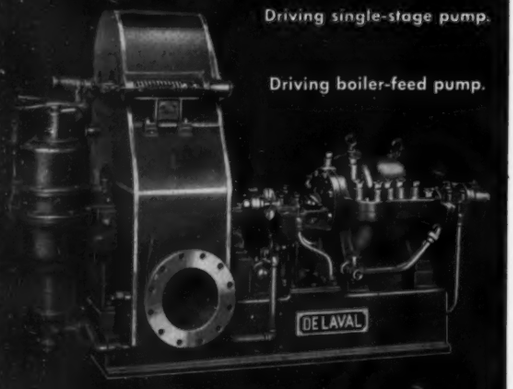
10 Advantages of DE LAVAL Velocity-stage TURBINES for Driving Auxiliaries



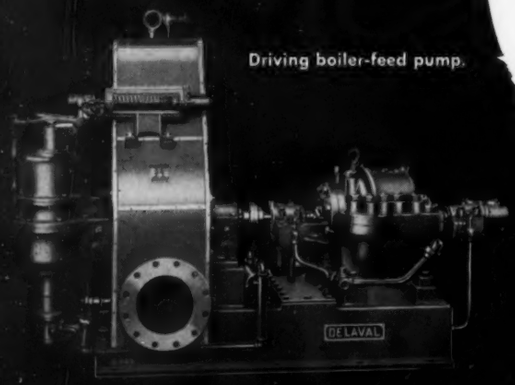
Driving boiler-feed pump.



Driving single-stage pump.



Driving boiler-feed pump.



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1 Most reliable; independent of electrical transmission line, generator and switchboard disturbances.

2 Create no fire hazard; cannot short circuit; sparkless.

3 Immune to hot or moist atmosphere.

4 Low maintenance and attendance costs.

5 Take the place of reducing valves.

6 Produce practically costless by-product power for heating or process steam.

7 Maintain heat balance with varying power and heat loads, avoiding waste of steam and unnecessary charges for electrical current.

8 Exhaust free of oil or grease.

9 Inexpensive as stand-by drives, always available while there is steam pressure.

10 Speed can be adjusted over a wide range, while still maintaining good efficiency.

Our engineers will supply information and advice upon receipt of data as to steam and power conditions in your plant. *ASK FOR PUBLICATION T-3528.*

DE LAVAL *Steam Turbine Co.*

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Driving boiler feed pump, as installed on oil tankers.

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STRAIGHT-LINE TAP CHANGER WITH SILVER TO SILVER CONTACTS GIVES PENNSYLVANIA POWER TRANSFORMERS UNSURPASSED RELIABILITY

★ NO HOT SPOTS

Silver contacts are capable of carrying heavy overloads and withstanding short circuits without overheating because of low initial contact resistance. No poor contacts can result from oxidation because silver oxide produces a negligible increase in contact resistance.

★ DURABLE

Hardness of silver contacts prevents harmful wear, even under continuous operation such as in a motor operated tap changer. Silver oxides formed on the contact surfaces will not increase the friction. SILVER CONTACTS WILL NEVER FREEZE IN POSITION.

★ EASY TO OPERATE

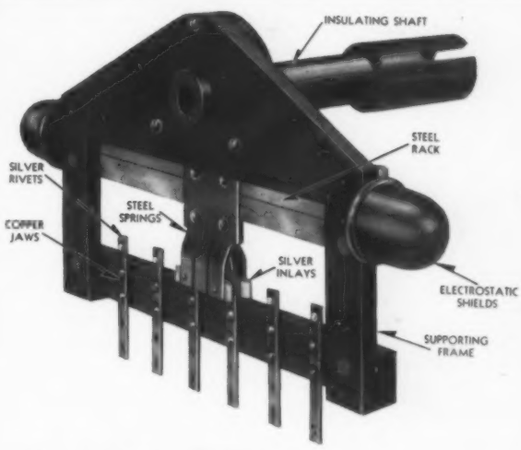
The direct connection of the shaft to the gear and use of a minimum number of bearings, plus the application of low friction silver contacts, result in a very low torque and an "easy to operate" tap changer.

★ SELF-ALIGNING

Pennsylvania Tap Changers possess a self-aligning feature which assures a high pressure contact at all times. This is accomplished by the special steel spring construction and straight-line motion of the movable jaw.

★ CORONA ELIMINATED

In higher voltage tap changers the elimination of corona is very important. This is accomplished in Pennsylvania Tap Changers by electrostatic shields of spun copper connected to the live parts of the tap-changer. Discharges due to corona are thus prevented.

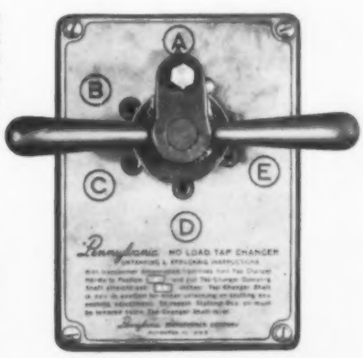


How it operates

The insulating shaft carries on its end a steel gear, which is hidden from view. This gear engages a cadmium plated steel rack. The rack carries two self-adjusting and self-aligning steel springs. On the end of each spring is mounted a copper jaw with silver inlays. The pressure of the spring is transmitted to the movable jaws which make contact by bearing against silver rivets imbedded in stationary copper jaws. The transformer leads are bolted on to the stationary jaws.

The supporting frame is fabricated of insulating material of great mechanical and electrical strength. Electrostatic Shields are provided on high voltage tap-changers to eliminate corona.

Tap positions plainly marked in large black letters on stainless steel guide plate. Tap Changer can be locked into any tap position.



NAMEPLATE AND OPERATING HANDLE

Pennsylvania
TRANSFORMER COMPANY
PITTSBURGH, PENNSYLVANIA

Pennsylvania TRANSFORMERS

LINCOLN

CENTRO-MATIC LUBRICATING SYSTEM

supplies lubricant to every bearing on a machine

EASY TO INSTALL

. . . No machinery alterations necessary

Avoid bearing failures . . . Cut war production delays . . . Lower your lubrication and maintenance costs by equipping your machines with Lincoln Centro-Matic Systems.

A Centro-Matic System consists of a number of Centro-Matic Injectors—one for each bearing—and a power operated or a hand operated Centro-Matic Lubricant Pump. A power operated system can be either time clock control or push button control . . . The injectors can be grouped in manifold or located separately at each bearing. In either arrangement only a single lubricant supply line is required . . . Easily installed on new or old machines . . . Please write for Bulletin 671, and send us blueprints of the machines you plan to lubricate. Our engineers will gladly make recommendations.

143-37

ARMY E NAVY

The **ARMY-NAVY PRODUCTION AWARD** for high achievement in the production of war equipment, conferred upon the Lincoln Engineering Company has had a star added. This star symbolizes 6 more months of exacting service to our Armed Forces, delivering vital materials so necessary for ultimate Victory.

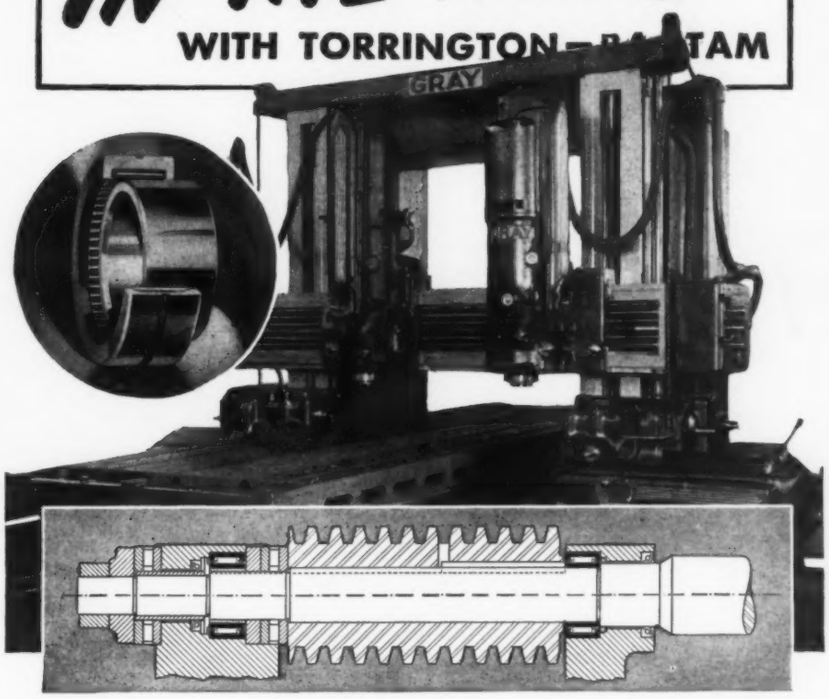
LINCOLN ENGINEERING COMPANY

Pioneer Builders of Engineered Lubricating Equipment

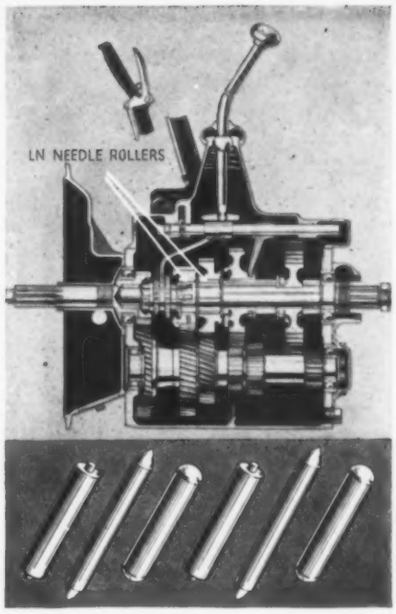
ST. LOUIS, 20, MO., U. S. A.

IN THE NEWS

WITH TORRINGTON—BANTAM

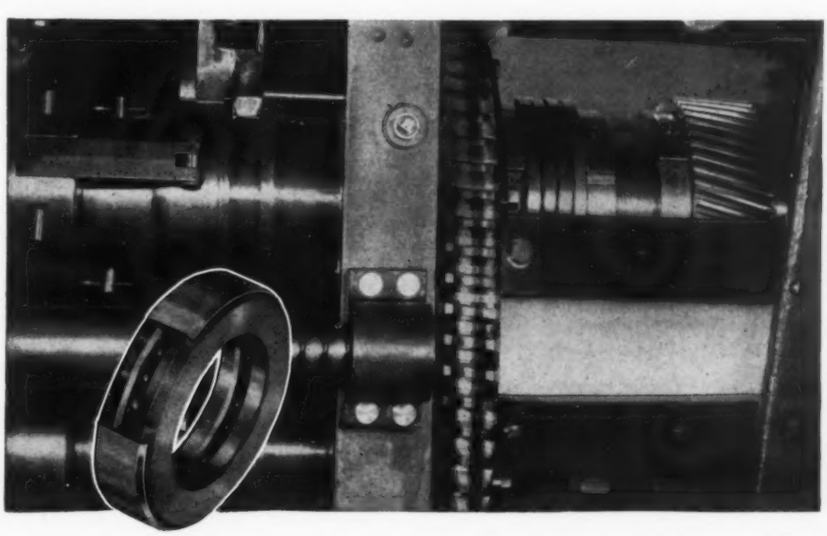


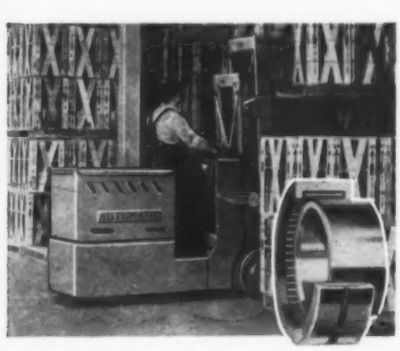
SPEED, FLEXIBILITY AND EASE OF CONTROL, usually confined to small knee-type machines, characterize this Planer Type Milling Machine manufactured by the G. A. Gray Company. Type NCS Needle Bearings and Roller Thrust Bearings are combined in an application on the spiral pinion mounting, as illustrated in the cross-section drawing. Because this pinion drives the heavy work and work table, and because torsional stiffness is a prime requisite, it is necessary to keep the pinion diameter small and the shaft diameter as large as possible.



UNUSUAL EASE IN SHIFTING, as well as quietness and long life under heavy service, are a few of the virtues of this Helical Gear Transmission manufactured by the Clark Equipment Company. The illustration shows the application of the high load capacity Type LN Needle Rollers on the mainshaft constant mesh gears, which contribute materially to the exceptional efficiency of this transmission. All types of Needle Rollers are included in the complete Torrington line. Our engineering department will be glad to make recommendations on the selection of the right type for your needs.

LIFTING TWO-AND-A-HALF TON LOADS is the job of the Standard Fork Truck illustrated here. Built by the Automatic Transportation Company, Type NCS Needle Bearings were selected for the sprockets at the top and bottom of the chain hoist which raises the telescopic uprights. Type NCS Needle Bearings with their high load capacity, ease of efficient lubrication and low friction coefficient are ideal for such heavy-duty applications.





SPEED FOR WARTIME PRODUCTION has been the result of increased output of machine tools such as this Four Spindle Automatic Lathe manufactured by the Cone Automatic Machine Company, Inc. Among the many engineering features that contribute to the outstanding performance of these automatic lathes is the use on the work spindles of two types of Special Thrust Ball Bearings built by the Bantam Bearings Division, one of them measuring 9" O.D., 6¼" I.D., and 1⅞" in thickness, and the other 8¾", 6", and 1⅞".

ARMY NAVY

TORRINGTON BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION

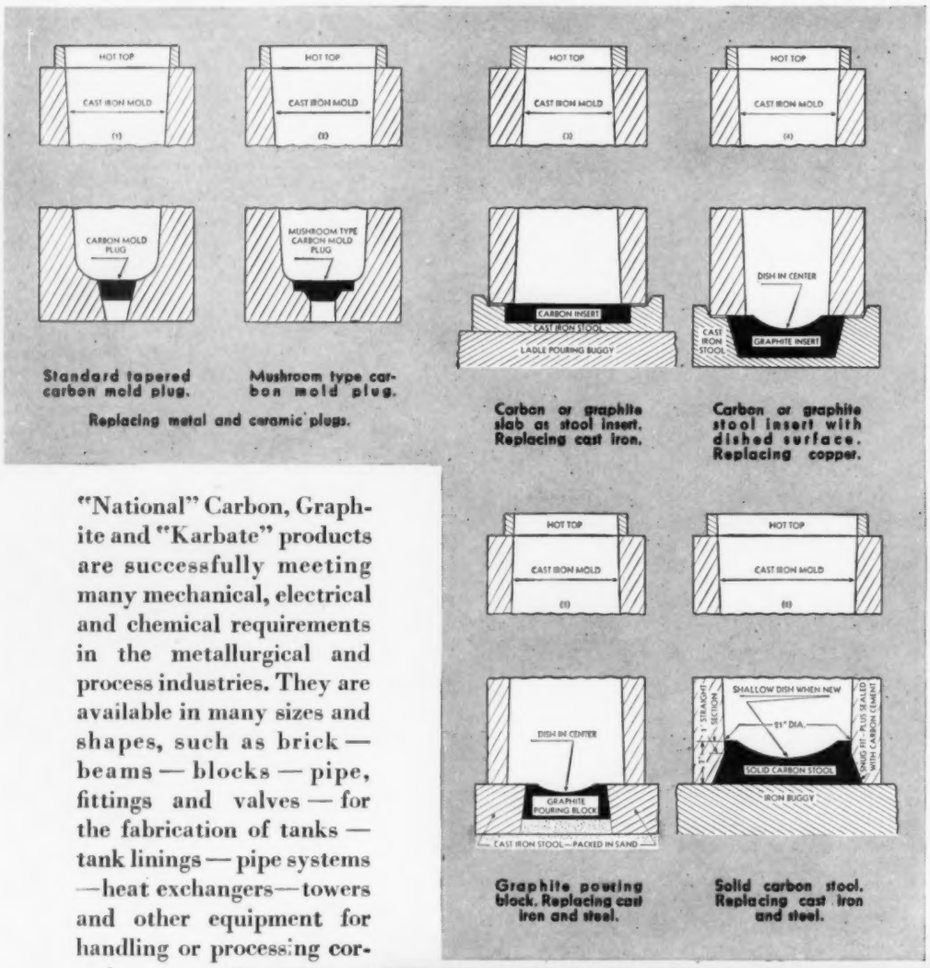
SOUTH BEND 21, INDIANA

Where Severe Thermal Shock is a Factor

Use Carbon and Graphite

EXPERIENCE HAS PROVED THE STABILITY AND EFFECTIVENESS OF "NATIONAL" CARBON AND GRAPHITE PRODUCTS WHEREVER SEVERE THERMAL SHOCK IS ENCOUNTERED.

STRENGTH . . MINIMUM OF CRACKING, SPALLING AND STICKING . . FREEDOM FROM INCLUSIONS OF FOREIGN MATERIALS . . LIGHT WEIGHT . . LONG LIFE . . LOW COST



Standard tapered carbon mold plug. Mushroom type carbon mold plug. Replacing metal and ceramic plugs.

Carbon or graphite slab as stool insert. Replacing cast iron.

Carbon or graphite stool insert with dished surface. Replacing copper.

Graphite pouring block. Replacing cast iron and steel.

Solid carbon stool. Replacing cast iron and steel.

"National" Carbon, Graphite and "Karbate" products are successfully meeting many mechanical, electrical and chemical requirements in the metallurgical and process industries. They are available in many sizes and shapes, such as brick — beams — blocks — pipe, fittings and valves — for the fabrication of tanks — tank linings — pipe systems — heat exchangers — towers and other equipment for handling or processing corrosive materials. Write for complete information.

are important advantages offered by these materials in such applications as ingot mold plugs, stool inserts, stools and pouring blocks (see sketches of typical applications). Mold and stool life have been prolonged and other economies made possible.

STANDARD TAPERED MOLD PLUGS

Standard tapered mold plugs are available in two sizes:

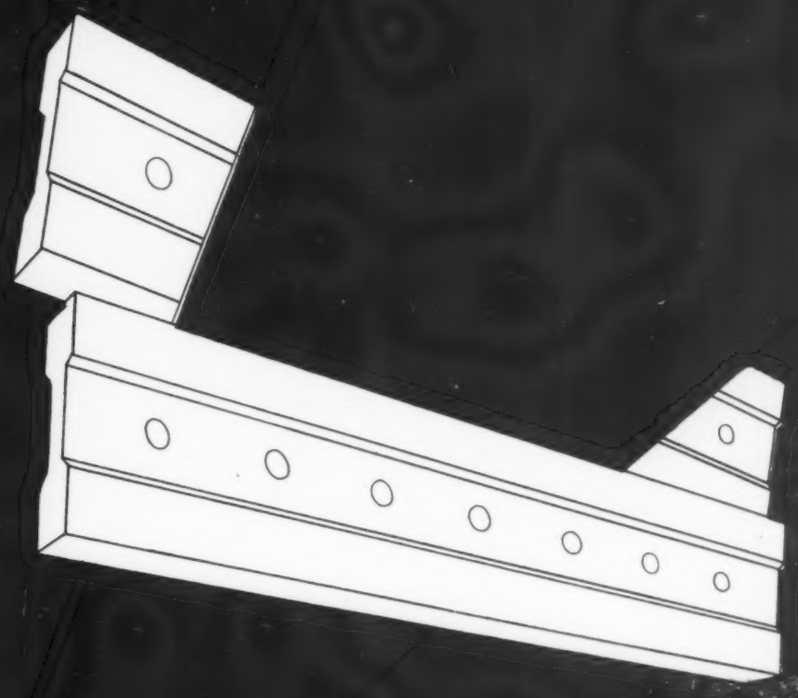
$5\frac{13}{16}''$ x $5\frac{1}{4}''$ x $3''$

$5\frac{15}{16}''$ x $5\frac{9}{16}''$ x $3''$

Other sizes and shapes of mold plugs, as well as stool inserts, stools and pouring blocks can be supplied to meet any desired specification.

The words "National" and "Karbate" are trade-marks of National Carbon Company, Inc.

NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
CARBON PRODUCTS DIVISION, CLEVELAND 1, OHIO
General Offices: 30 East 42nd St., New York, N. Y.
Branch Sales Offices: New York - Pittsburgh - Chicago - San Francisco



WAR PLAN...

for users of Shear Knives

A few simple precautions will extend the service life of a set of shear knives and permit the knives that would otherwise replace them to be used on some other vital job. These three suggestions will also decrease your "down" time and increase *your* war production.

(1) Specify the thickness and hardness of steel to be cut when *ordering* knives and after delivery never permit them to be used on products for which they were not designed.

(2) Before using shear knives be sure that the clearance between cutting edges is accurately adjusted for the thickness of steel to be handled.

(3) Specify Heppenstall Knives—they'll last longer. Heppenstall is the oldest and largest maker of solid tool steel knives and is able to offer greater precision in manufacture . . . They can also offer you faster delivery on lower priority ratings—an important consideration for any producer of war equipment.

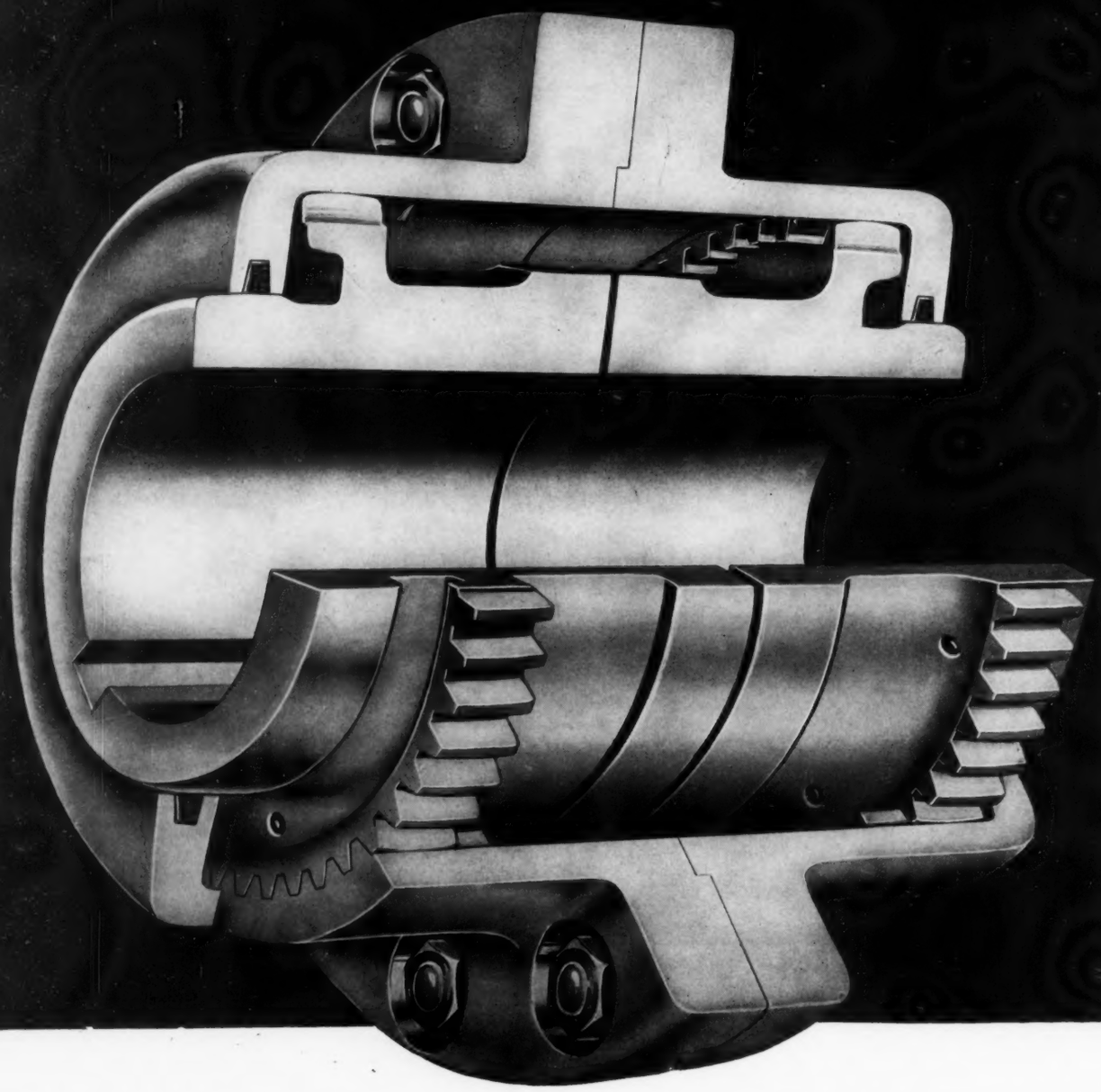
To help speed your war work, Heppenstall offers you this free steel-weight calculator. Write now—the supply is limited.

Heppenstall

PITTSBURGH • DETROIT • BRIDGEPORT
EDDYSTONE

Forging Fine Steels for Fifty-Three Years

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

Wagner

HYDRAULIC BRIDGE BRAKES

make crane operation safer and easier—

as expressed in the letter reproduced below, received from a mill worker employed in the plant of a well-known company.*

Wagner Electric Corp.,
St. Louis, Mo.

Dear Sirs: Recently a Wagner hydraulic brake was installed on a over-head crane I operate. This brake transformed my job from a nerve wracking grind, to a pleasant days work. No more brake chatter and vibration, which caused a break down ever so often, holding up production, as well as a tired out sick feeling at the end of every shift. With the Wagner hydraulic brake, I now can come to a smooth as well as an emergency stop; and depend on it to do just that. Anyone who operates a crane with a fairly fast run way speed, and averageing 300 lifts per shift would appreciate how important this is. After a dozen years of this work I find I enjoy doing it, thanks to your brake. Your company as well as mine are to be congratulated. You for building a fine piece of machinery, and my employer, for using the best.

*Name and address of writer will be sent upon request. (This letter is reproduced exactly as written).

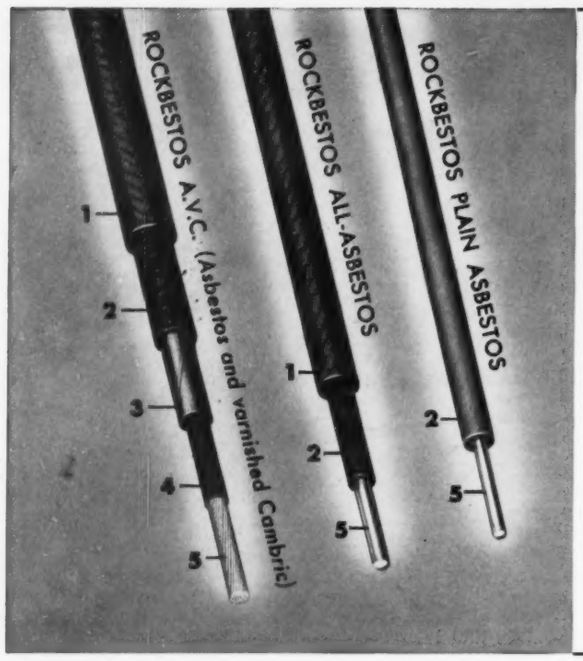
143-6

Write for Complete Information . . .

Bulletin IU-20 gives full information on the two available types of Wagner Hydraulic Bridge Braking Systems—type H for inside cranes, and type HM for outside cranes where automatic parking is necessary.

Wagner Hydraulic Bridge Braking Systems are complete in every detail, including all necessary parts and equipment, and are ready for immediate installation on your cranes.

Wagner Electric Corporation
ESTABLISHED 1891
6483 Plymouth Avenue, St. Louis 14, Mo., U. S. A.
ELECTRICAL AND AUTOMOTIVE PRODUCTS



3 GETS YOU 122

122 wires, cables and cords, stemming from the three basic designs illustrated, have been developed by Rockbestos to give trouble-free performance under severe operating conditions in steel mills, power plants, chemical industries, etc. Send for catalog to see the rest.

Rockbestos Permanent Insulation Insures Long-Lived Performance

1. A tough, rugged asbestos braid, resistant to heat, flame, moisture, oil, grease and corrosive fumes.
2. Felted asbestos insulation impregnated with heat-, flame-, and moisture-resisting compounds will not dry out, become hard and brittle, or burn. Also serves as a heat-barrier against high ambient temperatures.
3. Lubricated varnished cambric for high-dielectric strength and added moisture resistance, protected from heat, flame, and oxidation by felted asbestos walls.
4. Felted asbestos insulation that withstands conductor-heating overloads and won't burn even when exposed to copper-melting arcs.
5. The conductor is perfectly centered in helically applied insulation and will always remain so.

600 VOLT A.V.C. SWITCHBOARD WIRE—TABLE B

(Underwriters' Type AVB)

Sizes No. 18 to 4/0 A. W. G. with varnished cambric and felted asbestos insulation and gray, black, white or colored flameproof cotton braid.

Combine fire insurance and fine appearance in your switchboards with Rockbestos Switchboard Wire. It is absolutely fireproof and will not dry out under heat. Sharp, clean bends can be made without cracking as the asbestos wall acts as a cushion under the braid. Rockbestos A. V. C. Hinge Cable and Switchboard Bus Cable have the same fireproof and heatproof characteristics.

INDUSTRIAL HEATING CABLE—TABLE LH

No. 19 A. W. G. nickel-chromium wire insulated with .040" of felted asbestos and covered with 4/64" waterproof lead sheath.

This pliable cable distributes a mild heat evenly over a large area. Prevents freezing of water pipes, wet pipe sprinkler systems, etc. Keeps conveyor pipes for fuel oil, soap, varnish, ink, chocolate, etc., at temperatures that insure steady flow.

ASBESTOS INSULATED MAGNET WIRE

Round, square and rectangular asbestos insulated conductors finished to meet varying winding conditions and coil treatment requirements.

Protect your motors against heat-induced breakdowns with class B windings of Rockbestos Heat-Resisting Magnet Wire. Leads of A. V. C. Motor Lead Cable will complete the failure-proofing.

ALL-ASBESTOS FLEXIBLE CORD—TABLE CA

Sizes No. 10 to 18 A. W. G. with two or three conductors insulated with felted asbestos, covered with asbestos braid. Also in A. V. C. (asbestos and varnished cambric) constructions.

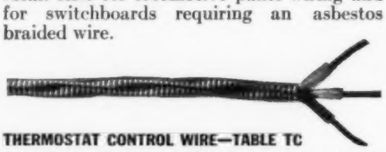
This heat-resisting flexible cord is ideal for high-wattage lighting units, floodlights, blueprint machines, apparatus, etc., which require a heavy duty, enduring cord. For moisture-resistant construction specify the A. V. C. type. Labeled cord with polarized conductors if desired.

600 VOLT A.V.C. BOILER ROOM WIRE—TABLE C

(Underwriters' Type AVA)

Sizes No. 18 to 4/0 A. W. G. This construction for sizes 18 to 8, sizes 6 to 4/0 have another wall of felted asbestos next to the conductor.

For lighting and control circuits exposed to heat and moisture, oil, grease, corrosive fumes or fire hazard, such as exist around furnaces, ovens, lehrs, soaking pits, boilers, etc., this widely used A. V. C. construction is ideal. Also for locomotive panel wiring and for switchboards requiring an asbestos braided wire.



THERMOSTAT CONTROL WIRE—TABLE TC

Sizes No. 14, 16 and 18 A. W. G. in two to six conductors with 12½, 25 or 31 mil wall of felted asbestos insulation and cadmium plated steel armor.

A multi-conductor control wire for low voltage intercommunicating, signal and temperature control systems. Its lifetime insulation and rugged steel armor will give you trouble-proof circuits.

600 VOLT ALL-ASBESTOS RHEOSTAT CABLE—TABLE R

(Underwriters' Type AI)

Sizes No. 18 A. W. G. to 1,000,000 CM insulated with a heavy wall of felted asbestos, covered with a rugged asbestos braid finished in black, white or colors.

Use this power and rheostat cable for wiring rheostats, switchboards, elevator and locomotive control panels and electrical equipment exposed to heat, fumes and fire hazard. Also for general open wiring in dry, high temperature locations. For solid conductor specify Rockbestos Rheostat Wire, Table A.

600 VOLT A.V.C. MOTOR LEAD CABLE—TABLE L

(Underwriters' Type AVA)

Sizes No. 18 A. W. G. to 1,000,000 CM insulated with two walls of felted asbestos and a high-dielectric, heat-sealed varnished cambric insert, covered with heavy asbestos braid.

Heatproof, fireproof, greaseproof and oilproof, will not dry out and crack, won't burn or carry flame, and remains permanently flexible. For coil connections, motor and transformer leads where extreme heat and fire hazards are encountered as in steel mills, etc.

600 VOLT A.V.C. CONTROL CABLE

In one to 19 conductors. Standard stranding A. W. G. No. 12—19/No. 25 and No. 9—19/No. 22. Other strandings furnished.

Designed for use under conditions too severe for control cables with other types of insulation which deteriorate rapidly when exposed to high temperatures. Operates without failure under the attack of heat, oil, grease or corrosive fumes and may be installed in conduit as it has ample moisture resistance.

600 VOLT A.V.C. POWER CABLE—TABLE E

(Underwriters' Type AVA)

Sizes No. 18 A. W. G. to 1,000,000 CM insulated with laminated felted asbestos, varnished cambric, and asbestos braid. Other constructions for service voltages to 8000.

Recommended for power circuits and hot spot wiring in or around boiler rooms, steam tunnels, soaking pits, tenter frames, glass plants, etc. The asbestos and heat-sealed varnished cambric construction has ample moisture resistance and withstands high temperatures.

Rockbestos Products Corporation, 913 Nicoll Street, New Haven 4, Conn.

WON'T bake brittle, bloom, burn or rot— RESISTS heat, moisture, oil, grease and fumes

ROCKBESTOS

The Wire with Permanent Insulation

FUEL EFFICIENCY PROGRAM TO COMBAT WASTEFUL PRACTICES

▲ Supplementing the Government's nationwide critical resources conservation campaign, Secretary of the Interior Harold L. Ickes has announced the launching of a fuel efficiency program to combat wasteful practices in the use of coal, coke, wood, petroleum and gas. Emphasis will be placed first on commercial and industrial plants, with the program to be expanded later to include small consumers, home owners and others.

He said that Dr. R. R. Sayers, Director of the Bureau of Mines, has named from private industry a National Fuel Efficiency Council of 12 engineers outstanding in the field of fuel utilization to chart and direct the campaign in cooperation with the Bureau of Mines. T. C. Cheasley, new supervising engineer of the Bureau's National Fuel Efficiency section, is chairman of the committee. In a recent preliminary meeting, at which the engineers pledged their services and outlined tentative plans, the council estimated conservatively that industrial, commercial, and domestic uses annually could save 29 million tons of coal alone by adopting known methods of efficient utilization. At present it is estimated that coal production in 1943 will not meet requirements, and increasing military needs are likely to cause a more serious shortage in 1944 unless production is increased and waste is eliminated.

Tentative plans call for the organization of subcommittees of engineers to carry out the program at regional and local levels. Hundreds of engineers already have expressed their willingness to cooperate. The assistance of national engineering societies and other organizations also is being sought.

The council will depend primarily upon education and training of industrial and domestic consumers to achieve results. The initial appeal will be made, largely by personal approach of local engineers, to commercial and industrial users. Group meetings among national trade and professional organizations also are expected to help.

Later the program will be expanded to include small consumers, home owners and others, with fuel-efficiency talks before established organizations supplemented by specialized literature and publicity through various media.

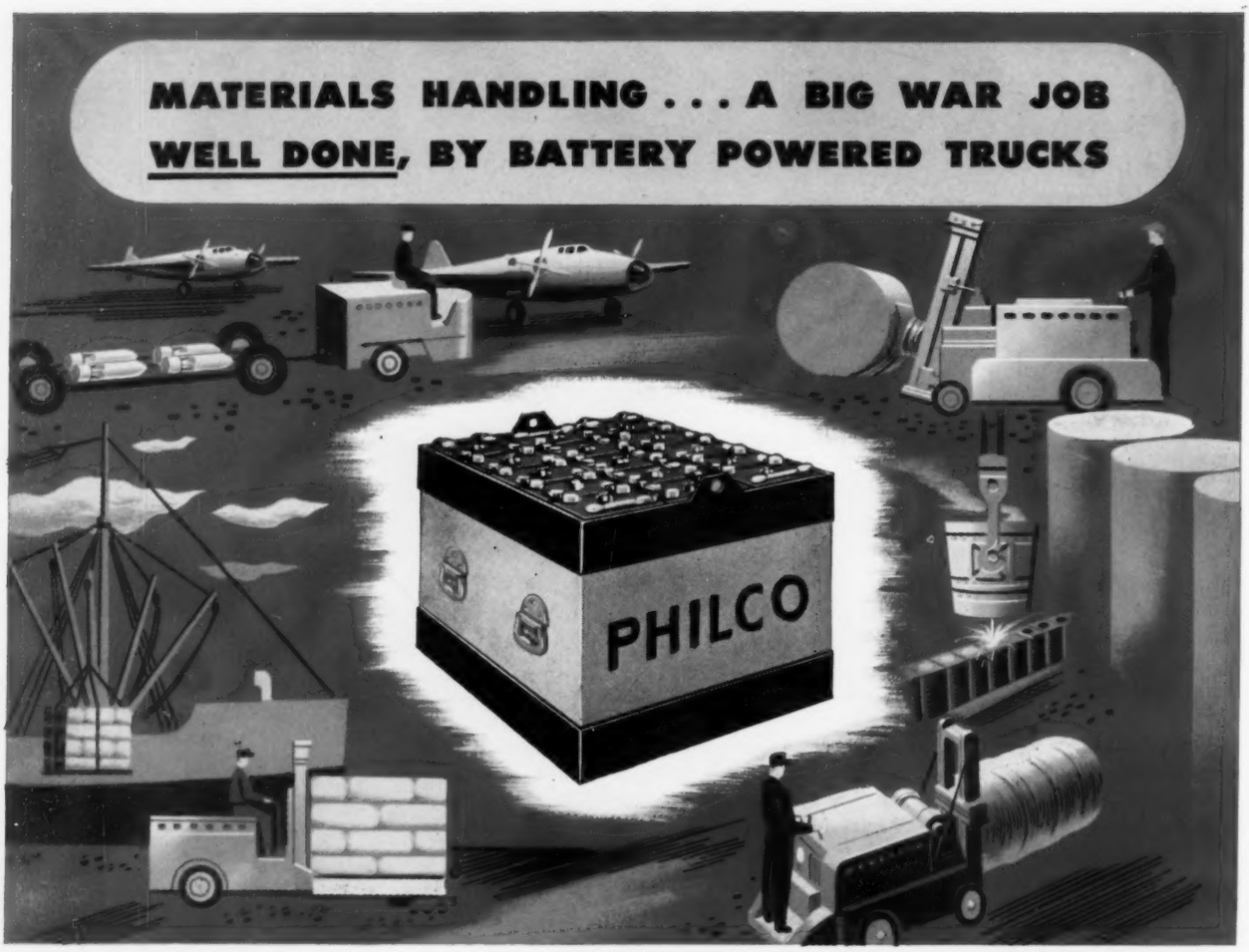
For several years, Great Britain has conducted a somewhat similar fuel-conservation program and is said to have achieved substantial savings.

NEW SECTIONAL HEAT EXCHANGER INTRODUCED

▲ The Brown Fintube Company of Elyria, Ohio, manufacturers of resistance-welded integrally-bonded fintubes and fintube heat exchangers, has introduced a new and improved construction of the popular and widely used sectional hairpin heat exchanger, said to offer many advantages never before available in these exchangers.

Featured in these new Brown fintube exchangers is a non-removable rear end assembly. The operator is required only to remove the bolts, back the cover plate off far enough to clear the plates of the adjacent "section," then swing the plate through a 180 degree arc and rebolt it in this position, to gain clear, unobstructed entrance into the exchanger. According to the company, this greatly simplifies installation and maintenance, since it avoids the use of any heavy cumbersome members and makes inspection and cleaning quick and easy, and therefore not so likely to be overlooked. Also, this

This massive tong, recently constructed by Heppenstall Company, Pittsburgh, for a major steel plant, has a lifting capacity of 80 tons. It was specifically designed for use in handling ingots, has an opening 69 inches wide and weighs 12,489 pounds. The tong is suspended from an overhead crane, and operates automatically, eliminating use of electric power and ground crews. The small tong, shown between the claws of the larger one, has a lifting capacity of 1,600 pounds, and is used for handling small material.

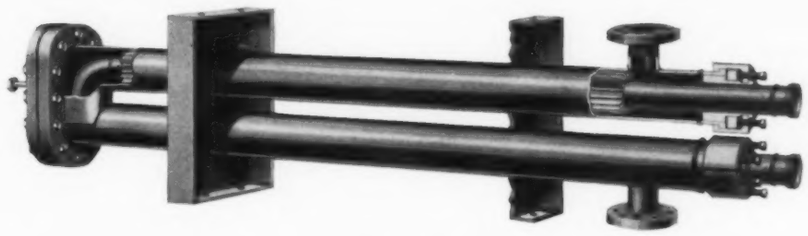


POWERED BY PHILCO "XL" BATTERIES, TRUCKS HAUL 10% MORE MATERIALS

IN war plants everywhere, electric industrial trucks are assigned the tremendous job of moving materials *where* they're wanted, *when* they're wanted! And everywhere, too, these trucks are powered with Philco "XL" Batteries because with a Philco in the battery box, trucks do 10% more work! Philco "XL" Batteries are engineered to give you 10% extra capacity with extra wallop... longer life... better performance, too. For complete details, write for latest Philco Industrial Truck Battery Catalog.

PHILCO CORPORATION
STORAGE BATTERY DIVISION,
TRENTON, NEW JERSEY
Sales Agents in all Industrial Centers

Replace with **PHILCO** *Industrial Batteries*



Sectional hairpin heat exchanger, designed for accessibility and high heat transfer.

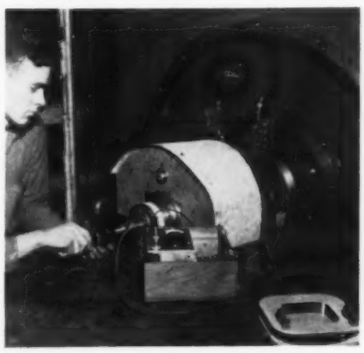
easy accessibility to the interior of the unit permits hairpins employing "plain longitudinal" or "cut and twisted" fintubes having different ratios of secondary to primary surfaces and different heat transferring capacities to be interchanged one for another as desired, so that a single stand of these improved sections can be used for a variety of different duties.

The new head seal introduced in these new exchangers, consisting of a solid ring and two split collars tightened with cap screws, can be assembled easily with only a conventional crescent wrench. This construction is said to avoid any outboard stress on the split ring lock, and tests — using a solid copper gasket — are said to have shown this construction capable of holding in excess of 2000 pounds pressure for days without trace of any "weeping."

In addition, these new exchangers have welded one-piece hairpins which positively prevent any mixing of the tube-side and shell-side fluids, and through the use of Brown Fintubes assures users of high thermal efficiency and trouble-free operation.

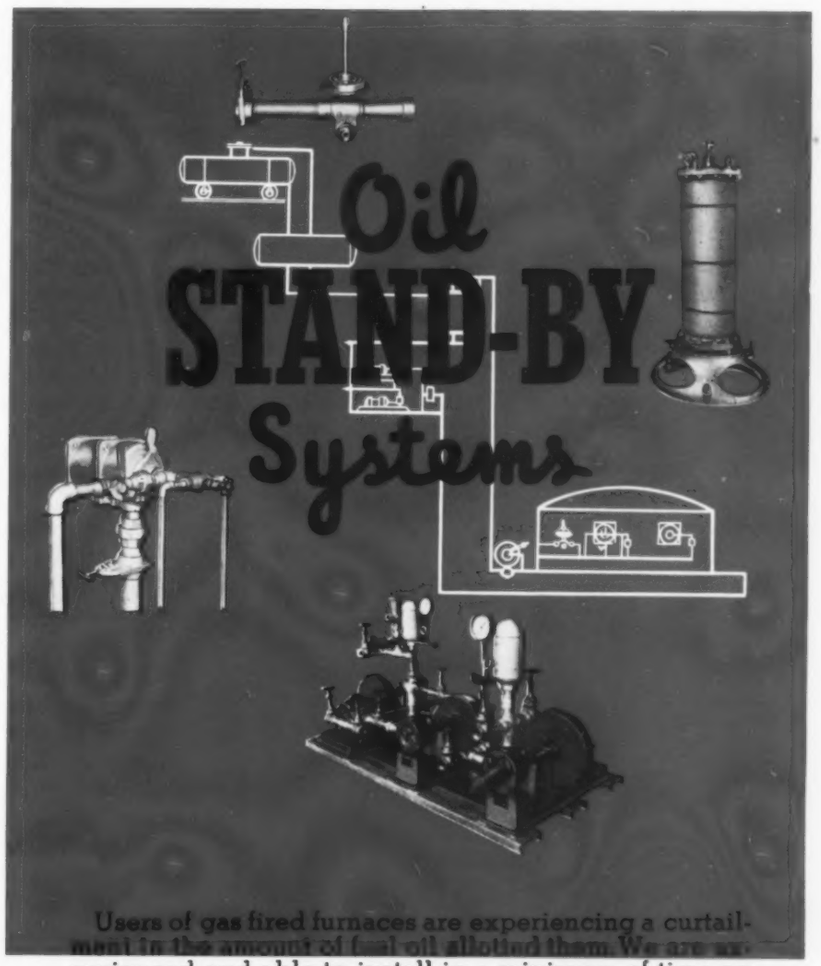
PORTABLE EQUIPMENT INDICATES UNBALANCE

▲ A small, compact General Electric balancing equipment weighing only a few pounds can help make the rotating masses of huge steel mill rolls, motors, generators, and turbines behave!



Portable dynamic balancing equipment in use on rotating machine.

When rotors of such machines are unbalanced, the resulting vibration causes excessive wear on the bearings and objectionable noise. It is imperative that the equipment be properly balanced in order to assure peak per-



Users of gas fired furnaces are experiencing a curtailment in the amount of fuel oil allotted them. We are experienced and able to install in a minimum of time an oil stand-by system complete ready for operation.

Why wait until a shortage occurs? Be prepared to switch at once to oil. Send your requirements and we will gladly quote on them.

TATE-JONES & CO., Inc.
LEETSDALE, PA.

TATE-JONES

Rotating Hearth, Car Bottom, Pusher, Conveyor, Roll Down, Horizontal and Vertical Pit, Circular and Rectangular Pot Furnaces
Also Gas, Oil and Combination Burners

formance and safety. There was a time when removing this dangerous vibration through proper balancing of rotating parts meant hours and hours of trial and error procedure.

The G-E portable dynamic balancing equipment consists of three principal parts — a sine-wave alternator, a vibration velocity unit, and an indicating unit and its associated circuits. When applied to rotating equipment, this balancing unit will measure the magnitude and the angular position of inherent unbalance weight while the rotating parts are running in their own bearings. As few as three trial runs of the rotating parts are required. With this information, calculations can be made to determine the amount and position of corrective weights which must be applied to the rotating masses to reduce the vibration.

PRECISE, EASY-TO-USE METHOD FOR INCHING SYNCHRONOUS AND SLIP-RING INDUCTION MOTORS

The Electric Machinery Company Incher is a precise, quick, easy-to-use method of spotting, or slowly rotating a 3-phase synchronous motor or slip-ring induction motor. Slow-motion, high-torque rotation of the motor is provided electrically by using commutated direct current to supply a slowly revolving 3-phase inching current to the motor. Inching is applicable to synchronous motors and slip-ring induction motors of any size or speed.

The Incher is particularly valuable in steel mills for positioning or rotating rolls for dressing and changing, backing out cobbles, providing or taking up slack, and for spotting for repair, or other purposes. The Incher accomplishes with ease and precision what otherwise is an awkward, time-consuming and sometimes costly job. "Nudging" or "goosing" the motor with the starter is destructive to starter switches . . . turning the motor with an overhead crane or other mechanical device is clumsy and slow. The Incher eliminates the need for either of these methods and does the job quickly and efficiently. Also, since

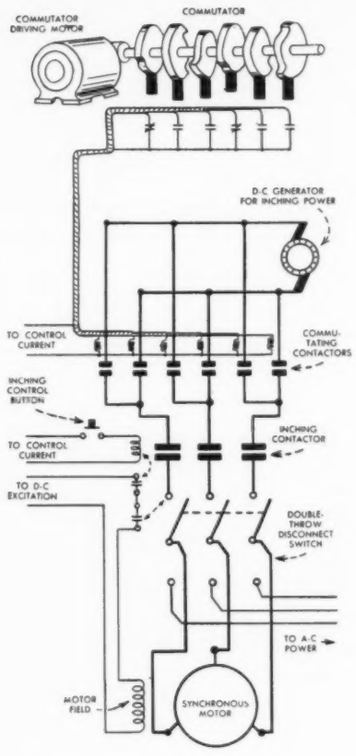


Figure 1

. . . A NEW UNIT FOR OILS REQUIRING ACID CORRECTION

Today lubricating oils on turbines and similar equipment are doing double duty. Production hours are longer . . . oils don't get a chance to rest or cool off. As a result acids and sludge build up . . . causing oils to be discarded or resulting in scored bearings, sludge formations in cooler tubes and machine pockets or governors. To help overcome these conditions, Bowser announces the new Oil Conditioning Unit. To acid-correct oils now in use. . . . to retard the formation of acid and sludge in new oils. Especially suited for auxiliary use with Bowser Type A and similar gravity filters . . . with Precipitation tanks . . . or, under some conditions, may be used alone. Extremely simple to install and to operate.

ARMY NAVY Buy WAR BONDS and STAMPS

SAVES OIL - SAVES EQUIPMENT

BOWSER OIL CONDITIONING UNIT FOR TURBINE & SIMILAR OILS

S. F. BOWSER & COMPANY, INC.

FORT WAYNE INDIANA

BOWSER

LIQUID CONTROL SPECIALISTS - SINCE 1885

METERING · DISPENSING · STORING · LUBRICATING · FILTERING · DISTILLING

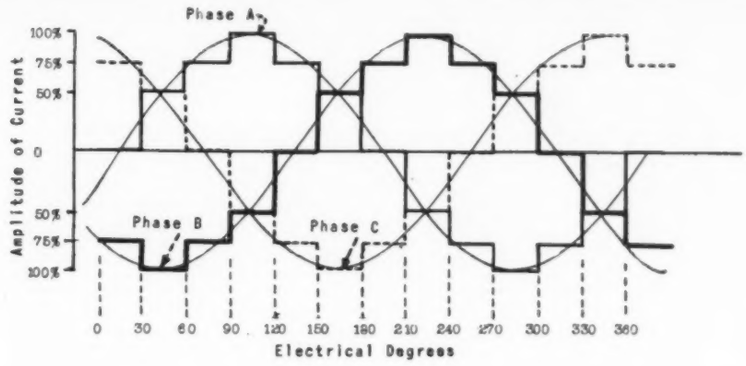


Figure 2

the Incher will revolve the motor in either direction, a reversing switch may be saved.

Equipment for the E-M Incher consists essentially of the following:

(1) Revolving commutator, turned by a small, adjustable speed, reversible motor.
(2) Commutating contactors, and main inching contactor for inching current to the motor.
(3) Push buttons and auxiliary control equipment.
(4) Double-throw disconnect switch for change over from a-c power to inching power.

In addition to the above equipment a source of direct current for inching power is required. This can be an existing source, such as a welding generator, motor generator set, or other source of suitable voltage capacity.

As the commutator is revolved, each cam disk closes its contact in appropriate sequence and duration to provide approximately a 3-phase inching current. For each 30 degrees movement of the commutator, commutating contactors are closed successively to supply amplitudes and phases of current to the motor as diagrammed in Figure 1. The successive amplitudes of current in the motor, in a given phase, are 0, 50%, 75%, 100%, 75%, 50%, 0, then repeating in a reverse direction, as shown by phase A, Figure 2 for example.

During inching the field winding of the synchronous motor is supplied with normal excitation. Or, in the case of a wound-rotor induction motor, the phases of the rotor winding are excited, through the collector rings, from a suitable source of direct current.

When inching current is supplied to the stator of the motor a series of north and south poles are set up in that stator, the number of which is the same as the number of poles on the rotor. Since the rotor is also definitely polarized by its excitation it will at once turn to line up its poles with those of the stator.

Then, as the inching commutator is rotated 30 degrees, the direct current is increased in amplitude in the phase windings of the motor, as illustrated in Figure 2, causing the polarities in the stator to shift forward by thirty electrical degrees. Thus, as the commutator is rotated, the poles in

Are you interested in Saving

MAN-POWER
FUEL
MATERIAL
This Gage will do it!

HAYS VISIO-RATIO GAGE

IT SAVES IN MAN POWER because it eliminates the necessity of making calculations to determine air excess or deficiency—does away with lost time in making experimental adjustments.

It saves in fuel because it indicates instantly when there is an incorrect proportioning of air and fuel. It is an infallible guide to highest possible combustion efficiency.

It saves in material through producing greater uniformity in production methods, in minimizing spoilage, etc. It may be used for indicating not only the ratio of air flow to fuel flow—but the ratio between other functions such as pressure, draft, suction, temperature (up to 1000° F) speed in R.P.M. or inches per minute, position, level and others.

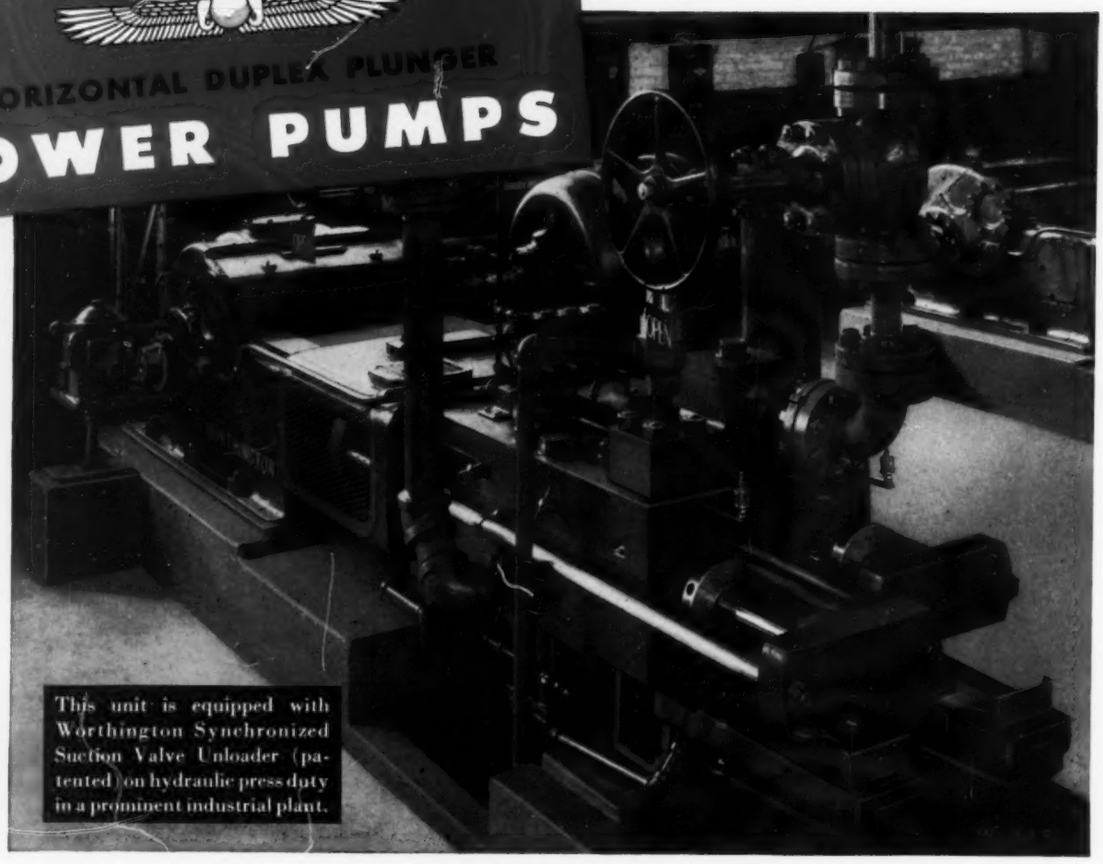
The cross-pointer feature is exclusive with the Hays Visio-Ratio Gage. It shows at a glance not only the amount of the two flows but the percentage of excess or deficiency existing between them.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

Send for
PUBLICATION 41-478
ON CENTRALIZED
CONTROL OF OPEN
HEARTH FURNACES

WORTHINGTON

HORIZONTAL DUPLEX PLUNGER POWER PUMPS



This unit is equipped with Worthington Synchronized Suction Valve Unloader (patented) on hydraulic press duty in a prominent industrial plant.

Note the following important features

- Totally enclosed, self-oiling, dust-tight power end
- Roller main and pinion-shaft bearings... no adjustment is necessary
- Loads are downward toward foundation
- All parts are near floor... full accessibility
- Metal-to-metal joint on all valve hole plugs... no gaskets to leak
- Heat-treated, drop-forged stainless steel valve service
- Extra deep stuffing boxes with lantern glands for packing lubrication
- Forged-steel liquid end bored from a solid forging

Worthington duplex double-acting plunger pumps, give long life in heavy-duty service . . . with minimum care. The electrically controlled synchronized suction valve unloader with which the pump illustrated above is equipped, establishes a new standard of hydraulic pump control, accomplished efficiently on the low-pressure suction side of the pump with no shocks and negligible maintenance. Bulletins W-412-B40 and W-404-B1 describing this equipment in detail are available on request.

Both the Navy E and Army-Navy E Awards have been presented to Worthington for speed and excellence in production.

PP3-1

WORTHINGTON

WORTHINGTON PUMP & MACHINERY CORPORATION • GENERAL OFFICES: HARRISON, N. J.

TRUMBULL-PIONEERED

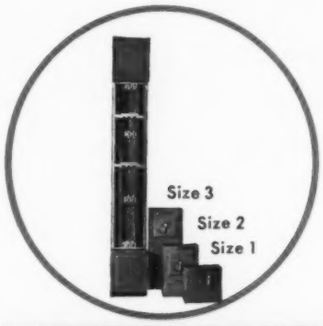
"packaged"

POWER CONTROL

(PREFABRICATED SWITCHBOARDS)

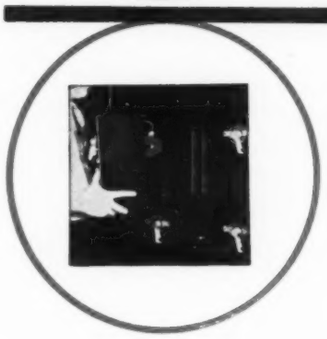
MAKES CONTROL CENTER INSTALLATION

Simple as **a b c**



a ORDER STANDARDIZED STOCK SECTIONS AND UNITS . . .

b ASSEMBLE & GROUP SECTIONS TO FIT YOUR NEEDS . . .



c PLUG IN REQUIRED CONTROL UNITS FROM FRONT

SAVES TIME . . . It used to take plenty of careful engineering and weeks of installation time to lay out power wiring and control equipment for a factory . . . until Trumbull pioneered application of the CONTROL CENTER idea. Now the engineering has already been done, and done well . . . on our time, not yours. You buy "packaged" units right out of stock. They are assembled, with almost "building block" simplicity, to give exactly the right combination of centralized switchboard or motor control equipment for your job . . . ready for power weeks or months sooner than possible under old-time schedules.

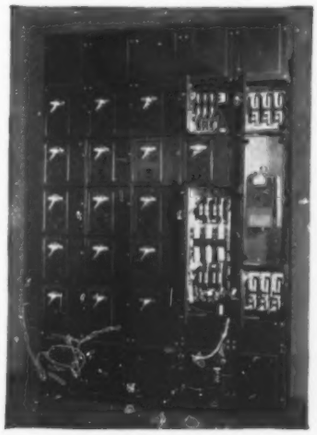
SAVES MATERIALS AND SPACE . . . Centralized Trumbull Control Center installations simplify feeder and machine wiring layout...use far less critical materials for a given load capacity, prevent waste in conduit and cable use. In large plants, control centers can be located centrally in production areas, BACK TO BACK OR AGAINST WALLS . . . requiring minimum space, all units, parts, and wiring connections ACCESSIBLE FROM FRONT . . . exclusive Trumbull features.

ASSURES FUTURE FLEXIBILITY . . . Vertical sections and interchangeable PLUG-IN TYPE control units provide flexibility never before possible . . . yet an exceedingly important factor in every plant today. Major revamping of an entire plant set up becomes possible by merely adding, subtracting or regrouping units and sections without any of the costly tie ups such work would ordinarily entail. Control Center installations made today provide the flexibility essential to war production and to later post-war reconversion.

This page merely covers the highlights. New Trumbullaid Bulletin No. 411 gives all the facts. Write for your copy today.

TRUMBULL

CONTROL CENTERS



THE TRUMBULL ELECTRIC MANUFACTURING COMPANY · PLAINVILLE, CONN. · A GENERAL ELECTRIC ORGANIZATION

OTHER FACTORIES AT NORWOOD (CINN.) O. — SEATTLE — SAN FRANCISCO — LOS ANGELES

the stator move along in thirty-electrical degree shifts and rotor will follow them. Speed of rotation, and direction are altered by changing speed or direction of rotation of the commutator.

Maximum motor inching speed in rpm will depend on the speed rating of the motor to be inched. For low-speed direct-connected steel rolling mill drives, a maximum motor inching speed of 1 to 2 per cent of the normal speed of the motor will usually be desirable, for higher speed motors higher inching speed may be necessary.

SILVER BABBITT HELPS WIN THE WAR

▲ When the history of this war is written, one of its most exciting chapters will be industry's quick conversion to new materials, to replace those no longer obtainable. Behind industry's doors, there is turning up every day some new discovery that is revolutionary but little talked about.

The creation of silver babbitt, for instance, is a direct outgrowth of the shortage of tin, due to the war. The Battelle Memorial Institute of Columbus, Ohio, deserves credit for exhaustive research to find a babbitt metal that is comparable to tin-base babbitts. The idea was to create a babbitt that would have the same bondability and corrosion resistance as that of tin-base babbitts and which would retain its hardness at operating temperatures without squeezing out. The answer was found in silver alloyed with a properly balanced lead base babbitt.

This new silver babbitt metal, is now produced by National Bearing Metals Corporation, St. Louis, Missouri, with the authorization of the Battelle Institute. Engineering briefs and a bulletin have been prepared by this company.

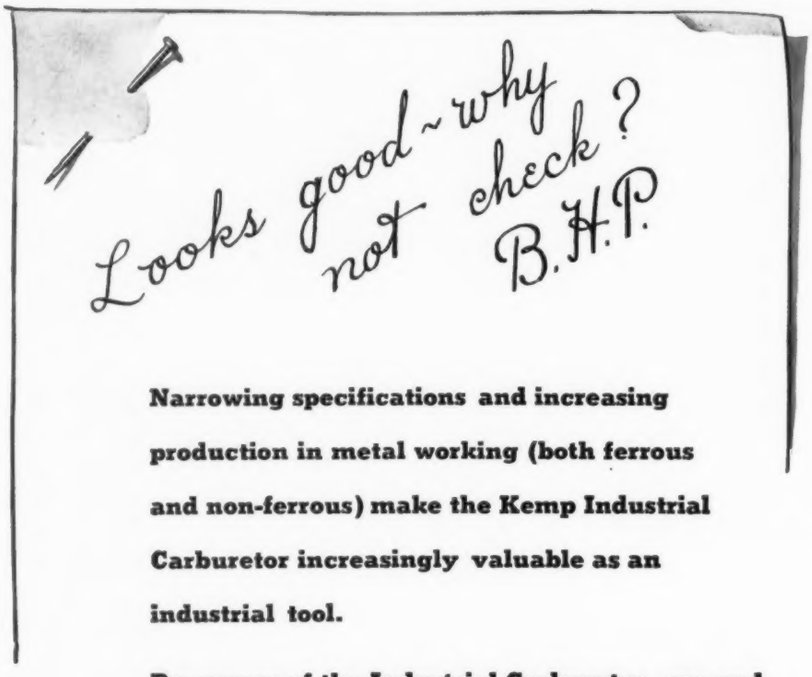
COMPANY TO MAKE WIRE MACHINERY

▲The Wean Engineering Company, Inc., announces that their subsidiary, The Broden Construction Company, Cleveland, Ohio, has entered into an exclusive arrangement with John A. Holmquist, of Aliquippa, Pennsylvania, to manufacture and sell the Holmquist line of machinery for the production of barbed wire, wire fencing, wire netting, wire mesh, wire bale ties, spools and reels.

This will augment the Broden line of wire drawing, galvanizing, tinning and other processing lines previously produced by them.

NEW UNIT FOR ACCELERATING GAS-AIR COMBUSTION REACTION

▲ One of the most important methods lately developed for accelerating the gas-air combustion reaction, is to enclose it wholly within a small insulating refractory cell with a restricted outlet opening, so distributing the combustion ports that the individual flames are projected along the ceramic walls of the enclosure, bringing them to brilliant incandescence. A typical unit developed by the Selas Company, Philadelphia, Pennsylvania, employing this principle is shown in cutaway perspective in the accompanying sketch, the entire element being as small as a packet of cigarettes. Because of the pressure developed within the unit, the violent cross-radiation from white-hot-wall to white-hot-wall, and the narrow ($\frac{3}{16}$



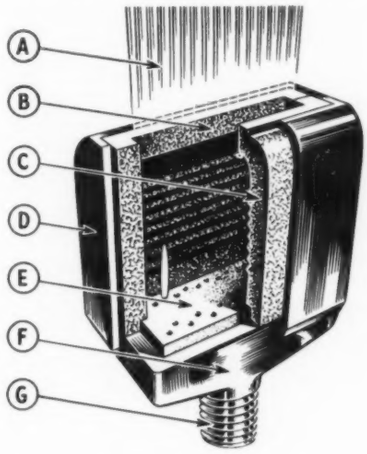
Narrowing specifications and increasing production in metal working (both ferrous and non-ferrous) make the Kemp Industrial Carburetor increasingly valuable as an industrial tool.

By means of the Industrial Carburetor, gas and air are *completely* premixed at a central station to provide any predetermined flame characteristics—reducing, oxidizing or complete combustion.

For descriptive bulletins, specific information or engineering assistance, address
The C. M. Kemp Manufacturing Company,
405 East Oliver Street, Baltimore-2, Maryland.

KEMP of BALTIMORE

in.) slot which is the only outlet for an undiluted stream of "super-heated" combustion products, it is possible to combust in the illustrated burner over 130 cu ft per hour of city gas



with an inlet mixture pressure of 2 psi. This amounts to a heat liberation of 68,000 Btu per hour within less than 2 cu in. — or 40 to 50 million Btu per hour per cu ft of combustion space.

FORK LIFT TRUCK HAS WIDE CAPACITY RANGE

▲ To provide a fork lift truck with a wider range of capacities for efficiently lifting, moving and stacking all types of materials, and at the same time to make production adjustments in line with wartime standardization programs authorized by WPB, Towmotor Corporation, Cleveland, Ohio, has developed a new model, designated LT-50.

Available in a 5000 pound capacity with either 104 in. or 144 in. lift, or in a 4000 pound capacity with 144 in. lift, model LT-50 replaces models LT-46 and LT-53 and rounds out the line of "one man gangs" offered in wheelbases of 40, 44, 50, 56, 62 and 72 inches and having corresponding ranges in speed, load and lift capacities.

Built with "balanced" specifications characteristic of all Towmotor models, the new lift truck is ideal for materials handling operations in many different fields. Maximum travel speed of model LT-50 is eight miles an hour; loaded lift speed is 40 ft per minute. A 50 in. wheelbase, outside turning radius of 92 in., overall width of 42 in., overall length (less forks) of 88 in. and center underclearance of 6 in. permit maximum maneuverability in close quarters, along narrow aisles and over steeply angled ramps. Standard fork equipment is of 36 in. length.

New Literature

▲ The Askania Regulator Company has just published a new bulletin titled "Askania Pressure Control." The bulletin describes completely the application of Askania regulator equipment to pressure and flow control problems. Installation photos and diagrams show how the equipment is used.

One of the features of the bulletin is the valve sizing chart. This chart, being published for the first time, shows how butterfly valve sizes may be determined in a quick and easy manner.

Ask for bulletin 100 by writing to the Askania Regulator Company, 1603 S. Michigan Avenue, Chicago 16, Illinois.

▲ "How To Keep Flowmeters Accurate" (Reprint 28) by Wm. C. Bennett of Cochrane Corporation, Philadelphia, Pennsylvania, is a practical guide to accurate metering. In its 8 pages, information is given on how to

500 TON WOOD STRAIGHTENING PRESS

This R. D. Wood hydro-lectric straightening press has an unusually simple single-lever control which permits fingertip operation. Ram direction can be changed instantaneously and the rate of speed accurately controlled by means of a special hydraulic unit to which the control lever is attached. Power up to 2500 lb per sq in. may be applied without shock or damage. This press is being used to straighten cast armor for tanks and sundry other straightening operations.

n·B·M BRONZE AND COPPER CASTINGS

Blast Furnace Copper Castings • Roll Neck Bearings • Housing Nuts • Machinery Castings • Acid Resisting Castings • Phosphorized Copper • Locomotive and Car Journal Bearings • Babbitt Metals

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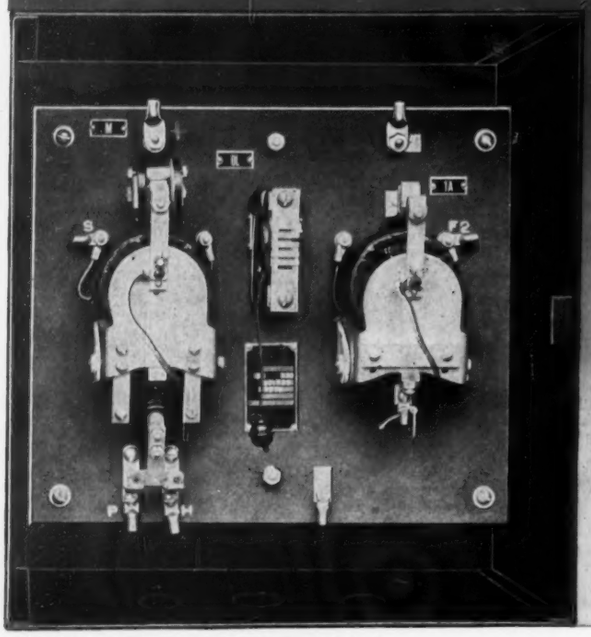
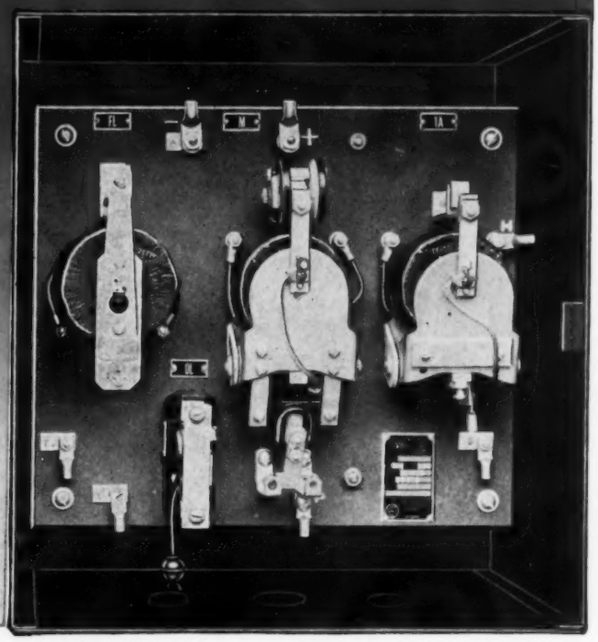
ON LAND OR SEA, THESE D. C. STARTERS GIVE SERVICE



"3C" BULLETIN 5370 TYPE P, FORM 2

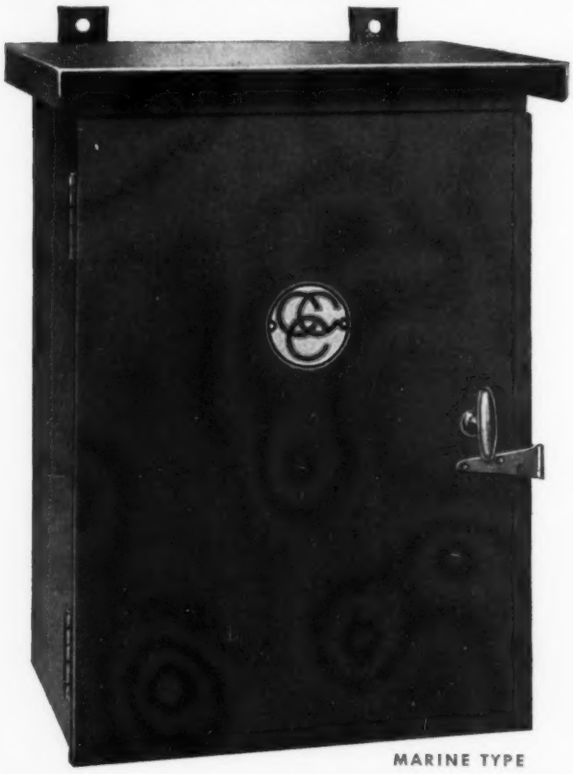


"3C" BULLETIN 5370 TYPE P, FORM 2L

On drives where frequent starting is needed "3C" Bulletin 5370 Heavy Duty Automatic Starters deliver SERVICE. They have "won their spurs" in heavy duty industrial service, and now have their "Sea Legs."

Just a few changes were needed—a drip-proof enclosure, corrosion resisting parts, control circuit fuses standard, Ebony asbestos mounting, and Bulletin 7400 D. C. Contactors counterweighted to prevent accidental opening or closing when ships are in high seas.

For Heavy Duty D. C. motor protection, use "3C" Bulletin 5370 Motor Starters.



MARINE TYPE

CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, 10, OHIO

★ Pyle-National plugs and receptacles are built for heavy duty service and proved by years of dependable performance in mills all across the country. Their substantial construction features include full bakelite insulation, protected contacts, and heavy steel or cast metal housings. These features mean uninterrupted service and safe, simple control of portable equipment circuits.

Pyle-National plugs and receptacles are available in a complete range of styles, sizes, and ratings for all types of applications, including styles particularly adapted to convenient handling of control and instrument circuits for operation of portable annealing furnaces and other heat treating equipment. The complete line includes styles for portable tools, signal and remote control circuits, extension lights, instruments, welders, shop tools, and many kinds of similar equipment.

Write for Pylet Catalog 1100 with complete listings of all types.

★ **General Purpose** plugs and receptacles: 1, 2, 3, 4, 5 poles; ratings 30, 60, 100, 200 amperes. Round prong contacts, rugged cast metal housings to withstand severe service.

★ **QuelArc** circuit breaking types: 2, 3, 4, 5 wire types, ratings up to 200 amperes. Exceptional protection to contacts for safe use as current rupturing devices.

★ **Triploc and Multiple Circuit** plugs and receptacles: 1, 2, 3, 4, 6 and 8 pole contact units, allowing assembly in combinations up to 32 poles. Manual and automatic release features. Ideal for portable tools, pyrometers, signal and control circuits.

★ **Midget Triploc,** compact, but with many exclusive heavy duty features for dependable service under severe conditions: 2, 3, 4 pole types.

★ **Battery Charging** equipment, designed for safe, convenient handling of industrial truck and tractor battery service.

PYLE-NATIONAL
ELECTRICAL EQUIPMENT
• SINCE 1897 •

THE PYLE-NATIONAL COMPANY
1334-58 N. Kostner Ave. • Chicago, Ill.
Offices: New York, Baltimore, Pittsburgh, St. Louis, St. Paul, San Francisco

CONDUIT FITTINGS • FLOODLIGHT PROJECTORS • LOCOMOTIVE ELECTRICAL EQUIPMENT

install flowmeters correctly and how to keep them accurate.

The author has achieved an intensely practical presentation, telling how to prevent and cure meter ills to the end that the flow charts of America's plants may do a 100 per cent job for today's War and tomorrow's Peace. Copies will be sent free on request.

▲ Cochrane Publication 2985-A describes an ingenious and simple method of proportioning sulphuric acid to water supplies. Accuracy is obtained without the use of any moving parts in contact with the corrosive liquid — giving long life and insuring very low maintenance charges.

The principle of operation is described fully, with its many advantages and applications in this publication, which can be had upon request.

▲ The Trumbull Electric Manufacturing Company of Plainville, Connecticut, has just issued a circular describing and illustrating their line of control centers, including motor control centers and switchboard control centers.

This literature brings up to date information on these control centers, which consist of vertical sections containing bus bars, into which are plugged combination control units of magnetic starters and disconnects, sizes 1, 2, 3 and 4, and switch and circuit breaker control units 30 to 600 ampere.

All these units are standardized and prefabricated — saving engineering time in layouts, conserving space, and reducing installation and operating costs.

▲ Published by General Electric Company, "How To Maintain Electric Equipment" contains tips on how to keep its equipment in top-notch condition. In its 372 pages, this book gives preventive maintenance schedules and trouble-shooting charts on almost all types of apparatus. More than 500 illustrations aid in telling how to get maximum performance and longest life. All material has been prepared by men with practical field experience. Cloth bound, $1.75.

▲ Charts to simplify the solution of heat-transfer problems in connection with refractories and high-temperature insulation are contained in a new 16-page booklet published by The Atlas Lumnite Cement Company, 135 East 42 Street, New York 17, New York. Curves on the ten full page charts are plotted in terms of conductivity factors. The novel arrangement makes it possible to use the charts for firebrick, insulating brick, refractory concrete, plastic refractories or any refractory material for which the conductivity (K-factor) is known.

The industrial furnace designer can use the charts for rapid determination of cold-face temperatures and heat losses. He can select the proper material — or combination of materials — and wall thickness to give a desired cold-face temperature or to minimize heat-loss. Efficiencies of two or more designs of furnace wall or flue lining can readily be compared. The curves are calculated in accordance with A. S. T. M. "Recommended Procedure for Calculating Heat Loss Through Furnace Walls."

Information on the conductivity factors of some common refractory materials is given with remarks on the reliability of test data and their practical usefulness.

CROUSE-HINDS
Gauge Lighting
CONDULETS

● **A complete line**—to meet every gauge lighting requirement.

● **Vaportight** gauge lighting Condulets for use in all indoor and outdoor locations where exposed to corrosive vapors, moisture, rain, smoke, or non-explosive dusts and gases.

Fluorescent lamps, Lumiline lamps or incandescent bulbs.

Round window or **light slots** 6, 13, 18, or 24 inches long.

Two or more units may be **tandem mounted** to give a continuous shaft of light.

Listed in Condulet Catalog No 2500, Section 25, Pages 17 and 18

● **Explosion-Proof** gauge lighting Condulets for use in Class I, Group D, hazardous locations.

Fluorescent lamps, Lumiline lamps or tubular lamps.

Light slots 7, 14, or 17 inches long.

Two or more units may be **tandem mounted.**

Listed in Condulet Catalog No 2500 Section 85, Page 16A

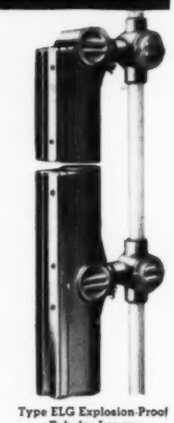
● **For ordinary locations**— Type LG gauge lighting Condulets for use wherever vaportight or explosion-proof fixtures are not required.

Incandescent bulbs.

Round or rectangular light opening, horizontal slot or vertical slots 5, 8½, or 13 inches long.

Installed with rigid conduit, round flexible cable, flexible conduit or armored cable.

Listed in Condulet Catalog No. 2500 Section 55 Page 13



Type ELG Explosion-Proof Tubular Lamps 7 and 14-inch Units Tandem Mounted

Type ELG Explosion-Proof Fluorescent or Lumiline

Type LG With Hooded Rectangular Light Opening

Type VFC Vaportight With Flanged 13-inch Slot

Type VLG Vaportight 18-inch Unit Fluorescent or Lumiline

Type VLG Vaportight 24-inch Unit Lumiline

A Nationwide Distribution Through Electrical Wholesalers

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SYRACUSE, N. Y., U.S.A.

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ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

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DATING
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In SAFETY STEEL Marking Stamps you'll find just the stamp to do the job! Clean, sharp, deep impressions are easily and quickly made on practically any shaped surface. Write for new literature.

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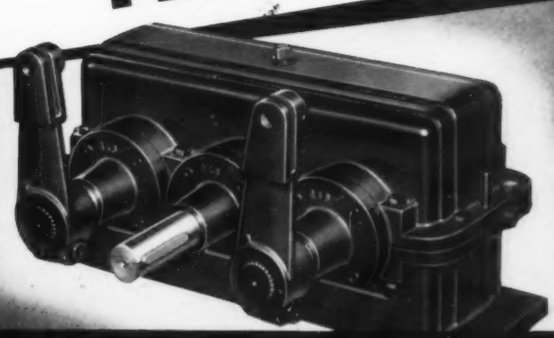
SAFETY STEEL STAMPS
105 EAST CARSON ST., PITTSBURGH, 19, PA.

Simple
SUMMARIZATION OF AIR REQUIREMENTS *for* **MULTI-FUEL FIRING**



ASKANIA'S
Summarizing Gear

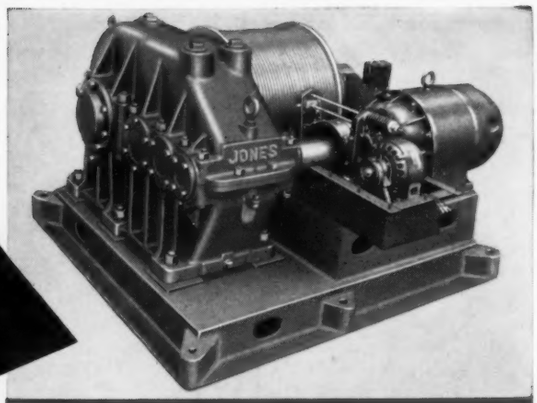
All the factors governing efficient multi-fuel firing such as . . . fuel characteristics . . . air infiltration . . . various atmospheres and flow impulses . . . are calculated and compensated for with absolute mechanical accuracy by the Askania Summarizing Gear. This device, in conjunction with the Askania Automatic Control System, provides industry with the most accurate, automatic control for any multi-fuel firing problem.

Full details upon request . . . write

JET PIPE PRINCIPLE

ASKANIA REGULATOR CO.
1603 S. MICHIGAN AVE • • • CHICAGO

When the drive is built into the unit



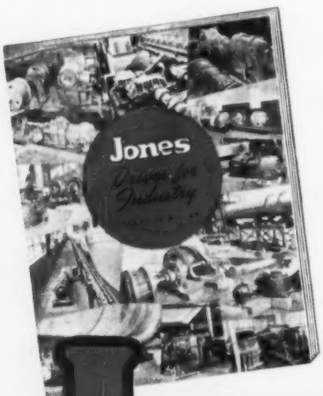
● Jones Skip Hoist Drive built as a complete unit by the Jones organization in several types with base to take any motor specified by the purchaser. This drive is equipped with all the modern protective devices such as cam or nut type limit switches, solenoid or disc type brakes and slack cable switches. The drives are single, double or triple reduction Jones Herringbone Speed Reducers.

FOR many years the Jones organization has been developing various types of drive units in which Jones special or standard speed reducers form an important integral part of the unit.

The car puller, door hoist and skip hoist drives illustrated and described here are typical specimens of Jones Unit Drives. These machines are built as complete units by the Jones organization with base to take any motor specified by the purchaser.

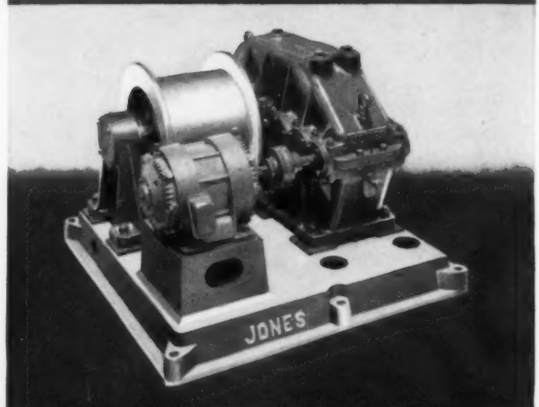
The Jones organization has also worked with a great many manufacturers in the application of Jones gears and speed reducers to an extremely wide variety of complete assemblies. You are invited to make full use of this experience in connection with any power transmission problems that you may have.

● Jones door hoists are built in many ratings and may be installed with almost any convenient arrangement of sheaves and cables. Base will take any standard motor. No limit switches of any kind are required with this unit.



W. A. JONES FOUNDRY & MACHINE CO.
4431 W. Roosevelt Road
Chicago, Illinois

Bulletin No. 80, "Jones Drives for Industry", may be helpful in giving you a complete picture of the Jones products, engineering services and manufacturing facilities that are available for helping you solve your drive problems.



● A complete Jones car puller unit. These outfits are for use with wire rope and are manufactured in a wide range of capacities to suit the number of cars to be handled in each plant.

Jones

HERRINGBONE—WORM—SPUR—GEAR SPEED REDUCERS ● PULLEYS CUT AND MOLDED TOOTH GEARS ● V-BELT SHEAVES ● ANTI-FRICTION PILLOW BLOCKS ● FRICTION CLUTCHES ● TRANSMISSION APPLIANCES

Cuno Keeps Descaling Spray Continuously Clean at Wheeling Steel

The difference between plugged or enlarged descaling spray nozzles and free, undamaged nozzles that help provide essential maximum production and also conserve valuable pumping power — is a Cuno Filter.

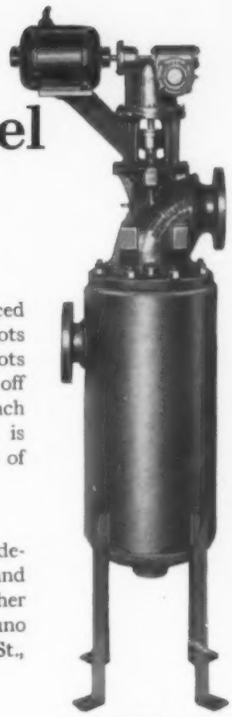
Used extensively in steel mill operations, Cuno Filters have proved to be excellent investments wherever fluids must be kept continuously clean in order to keep nozzles free and to prevent excessive wear from abrasive solids. And, engineered by Cuno means that the filter, in addition to positively cleaning full flow of fluid, is continuously cleanable itself, without interrupting production.

At Wheeling Steel Company, Steubenville, Ohio, high-pressure Cuno Auto-Klean strainers are placed close to the spray nozzles *ahead* of the hydraulic opening valves. The fluid passes between .020″-spaced stainless-steel discs, and, during the two to three minute period when high pressure is off, motors automatically turn the cartridge of discs past stationary cleaner blades which extend between the cartridge discs and comb out all accumulated solids.

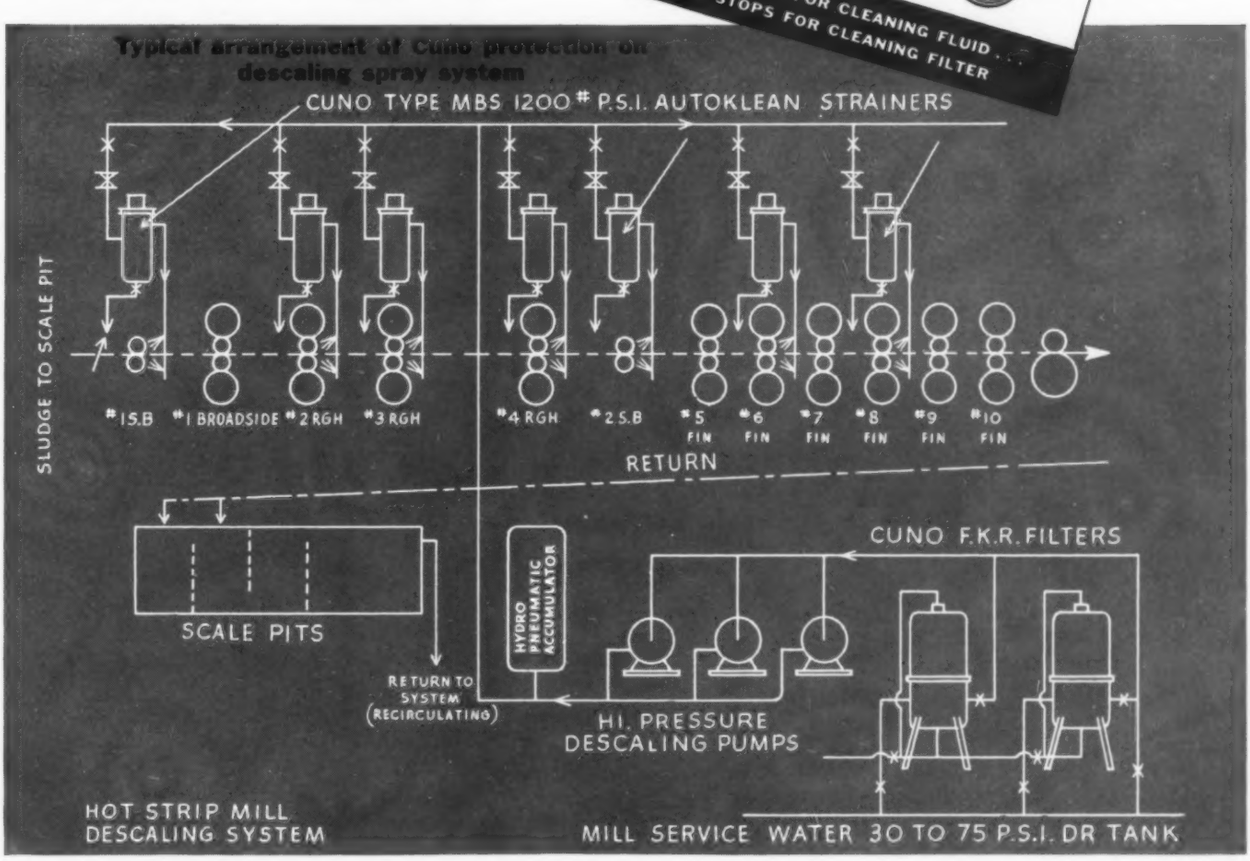
In certain localities or under conditions where the original water supply is contaminated, Cuno Flo-Klean filters (backwash type) are also placed ahead of the pumps. The fluid flows through slots between wires, and all solids larger than the slots are retained on the outer surface to be cleaned off regularly by momentary reversal of flow at each section of the filter element. No shut-down is necessary for this cleaning, so there is no need of expensive duplex installations.

New Booklet Explains Other Uses

"Quick Facts", a new, free Cuno booklet, describes complete advantages of Auto-Klean and Flo-Klean construction and suggests many other uses in keeping fluids on "Go." Write Cuno Engineering Corporation, 910 South Vine St., Meriden, Connecticut.



Cuno MBS Auto-Klean—the type used by Wheeling Steel Company.



ITEMS OF INTEREST

Peer D. Nielsen has been appointed general superintendent, and **Clifford G. Strote,** purchasing agent, of the Geneva Steel Company, United States Steel Corporation subsidiary with headquarters at Geneva, Utah.

Mr. Nielsen, who, until recently, was chief engineer of the Lorain (Ohio) Works, National Tube Company, began his service with U. S. Steel Corporation subsidiaries in 1924 in the chemical laboratory and open hearth department of the Lorain plant. He became, successively, assistant open hearth metallurgist, assistant open hearth superintendent, steel works superintendent and advanced to the position of chief engineer in 1941. He obtained his technical training at the University of Michigan and at Lehigh University, where he graduated with a degree in Metallurgical Engineering.

PEER D. NEILSEN

A native of Rockford, Illinois, Mr. Strote had his earlier business training with the National Lock Company of that city, serving from 1930 to 1938 in various capacities, including that of purchasing agent. From 1938 to 1942, he was employed by Griffith Construction Company, Camp Grant, Illinois, and the construction firm of Boyle and Healy, Carbondale, Illinois, as assistant purchasing agent. In March, 1942, he became assistant purchasing agent in the defense plant division of Columbia Steel Company, a United States Steel subsidiary.

A. H. Philpot has been made assistant to the president, Warren Division, Copperweld Steel Company, Warren, Ohio. Mr. Philpot has been in charge of the company's Steel Division office in Washington and will continue to make his headquarters there. Previous to his connection with the company, Mr. Philpot was with the Republic Steel Company.

James K. Sutherland, assistant general superintendent of the Youngstown Sheet and Tube Company's Youngstown plants, has resigned to become assistant general manager of all works of National Steel Company.

Mr. Sutherland joined Youngstown Sheet and Tube in 1909 as a soaking pit craneman, advancing to shearman then roller. He helped to make and roll the first open hearth steel made by Sheet and Tube.

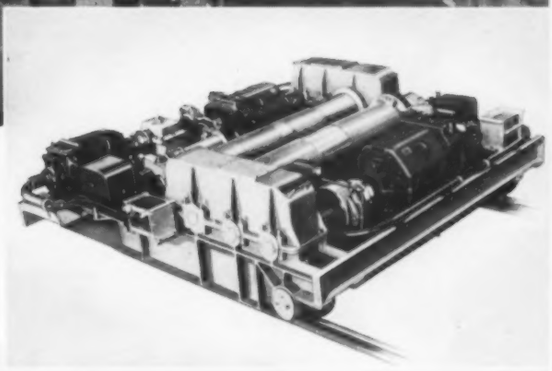
In 1922 Mr. Sutherland became superintendent of the billet bar and blooming mills for Brier Hill Steel Company. In 1927 he was moved to Campbell in charge of skelp, blooming, bar, billet and puddling mills. When the wide strip mill was built in 1935, he was put in charge of that and in 1936 was made assistant general superintendent of all works.

JAMES K. SUTHERLAND

W. E. Addicks has been appointed as manager of the New York district office of Cutler-Hammer, Inc. In his new duties Mr. Addicks will have direct supervision of sales for the company in the entire New York sales territory. His wide background of experience with the company has made him especially well suited for his new appointment.

Mr. Addicks entered the employ of Cutler-Hammer, Inc. as an engineer immediately after he graduated from Cornell University in 1914, and for ten years he served as chief engineer at the New York Works. Prior to his new appointment Mr. Addicks was in charge of the Boston sales office.

J. Frederick Wiese was elected a vice-president of Lukens Steel Company, Coatesville, Pennsylvania. Mr. Wiese will be in charge of the combined sales of Lukens and its two subsidiaries, By-Products Steel Corporation and Lukenweld, Inc. Since June, 1939, Mr. Wiese has been general manager of sales of Lukens Steel Company



MORGAN 60-TON, 100′ 0″ SPAN HEAVY-DUTY MILL TYPE CRANE

BUILT BY MORGAN *Engineering*

● Illustrated is one of two Morgan heavy-duty mill type cranes in a strip mill. Morgan superiority of design and construction is built into every part to insure many years of profitable service. They are equipped with fabricated welded trolleys and bridge trucks, hydraulic bridge brakes and anti-friction bearings throughout. Trolleys are of the gear box type using plain motors with flexible couplings. An auxiliary girder is provided for helping to support the cage, bridge motor and control units. Morgan engineers rely upon a highly skilled shop organization, modern equipment and progressive ideas in building heavy-duty mill type cranes.

THE MORGAN ENGINEERING CO.
ALLIANCE, OHIO. Pittsburgh, 1420 Oliver Bldg.

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

You can count on the AMERICAN LOCOMOTIVE CRANE to stay in there and PITCH

Modern industrial plants with urgent war production schedules cannot afford even a short tie-up of an important machine for repairs.

The construction of the

AMERICAN LOCOMOTIVE CRANE

Is real assurance of uninterrupted production:

1 Anti-Friction Bearings, built to last as long as the crane.

2 Ability to throw hoist and swing gears out of mesh when traveling, greatly reduces wear.

3 Fully enclosed Universal Joint Travel Mechanism runs in oil.

4 Three-Speed Transmission runs in an oil bath.

5 Roller Bearing Turntable completely enclosed and drip lubricated; practically no wear.

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AMERICAN TERRY DERRICK CO. . . . South Kearny, N. J.

and subsidiaries. Before joining Lukens, he was with the Chicago sales office of the Parkesburg Iron Company, Parkesburg, Pennsylvania.

Richard C. Bachman has been appointed as manager of the methods in the engineering bureau and **Alexander S. Chalfant** as assistant to the chief industrial engineer in charge of planning of Carnegie-Illinois Steel Corporation.

Mr. Bachman in 1932 received a Bachelor of Science degree in mechanical engineering at Princeton University. He formerly was associated with a national advertising concern.

Mr. Chalfant in 1933 received a Bachelor of Science degree in industrial engineering at the University of Pittsburgh. He has been employed by Carnegie-Illinois ever since. He was plant industrial engineer at the company's Duquesne Works since May 1940.

Carl Luth, 50, who has been serving as acting chief engineer at Duquesne Works, Carnegie-Illinois Steel Corporation, has been made chief engineer at this U. S. Steel subsidiary plant in a series of engineering division personnel shifts.

Mr. Luth began his service with Carnegie-Illinois in 1915 at Edgar Thomson Works, where he advanced to the post of assistant chief engineer. In 1940 he joined the engineering staff at Duquesne in a similar capacity.

J. N. Von Behren, 41, has been transferred to the staff of the chief engineer of the company's Pittsburgh District, where he will handle special assignments. He was formerly project engineer at Duquesne. Born in St. Louis, Mr. Von Behren received his technical education at Washington University of that city.

UNCLE SAM SAYS:

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DACAROL will help you to comply with the recent request of the United States Government to conserve fuels.

EVERY USER OF FUEL OIL HAS EXPERIENCED:

— clogged oil lines, preheaters, strainer, burner tips, etc.
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— the evil effects of sludge in the oil system.

DACAROL fuel oil treatment will eliminate these undesirable conditions. It dissolves deposits. It prevents future formation of deposits.

TRY IT IN YOUR OWN PLANT—
THEN JUDGE FOR YOURSELF

DACAR PRODUCTS

DACAR CHEMICAL PRODUCTS COMPANY

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Pittsburgh, Pa.

Gustave G. Erland, 35, assistant project and presentation engineer, defense engineering staff, Pittsburgh District, moves to Duquesne as assistant chief engineer. His service with the company dates from August 1930, when he joined the engineering staff at South (Chicago) Works. He attended Armour Institute of Technology, Chicago, and the John Marshall Law School.

Obituaries

George Tallman Ladd, president of United Engineering and Foundry Company, died at Pittsburgh October 3. Mr. Ladd's first association was with the Motive Power Division of the Pittsburgh and Lake Erie Railroad Company, Pittsburgh. From 1910 to 1925 he was head of his own engineering firm at Pittsburgh, and was president of the Ladd Water Tube Boiler Company from 1925 to 1928. During this period he made numerous contributions to the application of high pressure steam generating units in modern power plants. Mr. Ladd became president of the United Engineering and Foundry Company in 1928. He was chairman of the board of the Pittsburgh Testing Laboratory, and Woodings-Verona Tool Works, Verona, Pennsylvania, and president and treasurer of the Ladd Equipment Company, Pittsburgh. He was also chairman of the executive committee of the Pennsylvania-Central Airlines, and a member of the executive committees of Pittsburgh Steel Company, National Supply Company, Follansbee Steel Corporation, Westinghouse Airbrake Company, Union Switch and Signal Company, and several others.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

IRON AND STEEL ENGINEER

(Required by Act of Congress of August 24, 1912)

Name of Publication: *Iron and Steel Engineer*, published monthly at Pittsburgh, Pa. (Report of October 1, 1943.)

Editor: Brent Wiley, Empire Building, Pittsburgh, Pa.

Business Manager: James D. Kelly, Empire Building, Pittsburgh, Pa.

Names and addresses of stockholders holding 1 per cent or more of total amount of stock: None.

BOARD OF DIRECTORS
1943

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First Vice-President, C. L. MCGRANAHAN, *Assistant General Superintendent*, Jones and Laughlin Steel Corporation, Pittsburgh Works, Pittsburgh, Pennsylvania.

Second Vice-President, J. L. MILLER, *Assistant Chief Combustion Engineer*, Republic Steel Corporation, Cleveland, Ohio.

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W. H. COLLISON, *Superintendent*, By-Product Coke Plant, Great Lakes Steel Corporation, Ecorse, Michigan.

L. R. MILBURN, *Electrical Engineer*, Great Lakes Steel Corporation, Ecorse, Michigan.

A. W. STEED, *Superintendent, Maintenance*, American Rolling Mill Company, Middletown, Ohio.

A. S. GLOSSBRENNER, *Geenral Superintendent*, Youngstown District, Youngstown Sheet and Tube Company, Youngstown, Ohio.

Managing Director, BRENT WILEY, Empire Building, Pittsburgh, Pennsylvania.

Known bondholders, mortgages and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities: None.

JAMES D. KELLY, Business Manager.

Sworn to and subscribed before me this sixth day of October, 1943.

G. WILLIAM JONES, JR., Notary Public

(My commission expires February 9, 1947.)

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FLEXIBLE COUPLINGS
are taking a vital part in winning the war!

. . . Because of their exclusive features Thomas Flexible Couplings are used on many of our nation's tools of war, as well as in the manufacturing of them. Since there are no wearing parts backlash is eliminated and lubrication is unnecessary.

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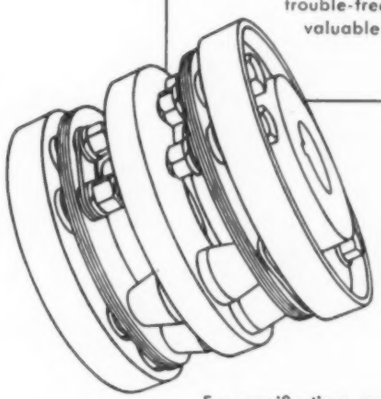
No other type or make of coupling provides these features, essential to longer life and trouble-free service of valuable equipment.



For specifications on couplings for all standard purposes write (on your letterhead) for the new Thomas Catalog with complete engineering data.

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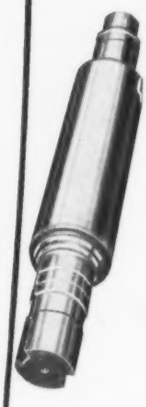
PATIENCE or TROUBLE

ALL rolls are designed and manufactured to produce a fair range of tonnage, and if forced beyond a reasonable output without resurfacing, will usually show the strain of such abuse.



Thus on all normal occasions, the desire for large output should be tempered with patience — and after a reasonable run, the rolls should be re-conditioned, as such treatment preserves the original condition of the implements and extends their life and tonnage potential.

NATIONAL ROLLS are made to achieve steady, reliable output in the task for which they are designed, and their hardness of surface, basic strength and smooth, precise finish merit the confidence of operating executives.

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All Grades of Plain and Iron Alloy Rolls—Both Chill and Grain Types
Heavy Iron Castings and Rolling Mill Equipment

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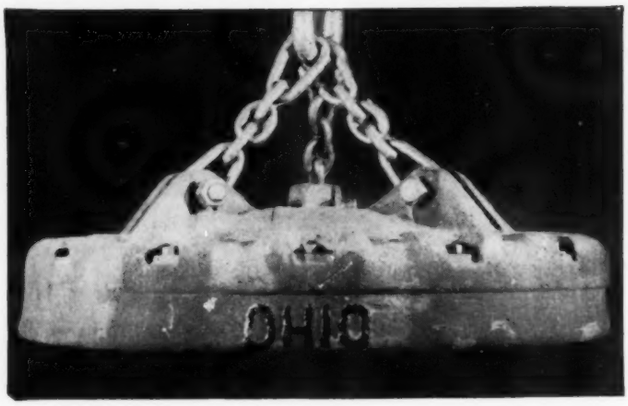
A 17 Year Old Ohio Magnet



Outer ring worn down 4 inches but not cracked. Water finally got in and grounded coil.

Ohio Magnets give long service at low maintenance cost.

OHIO reliable MAGNETS

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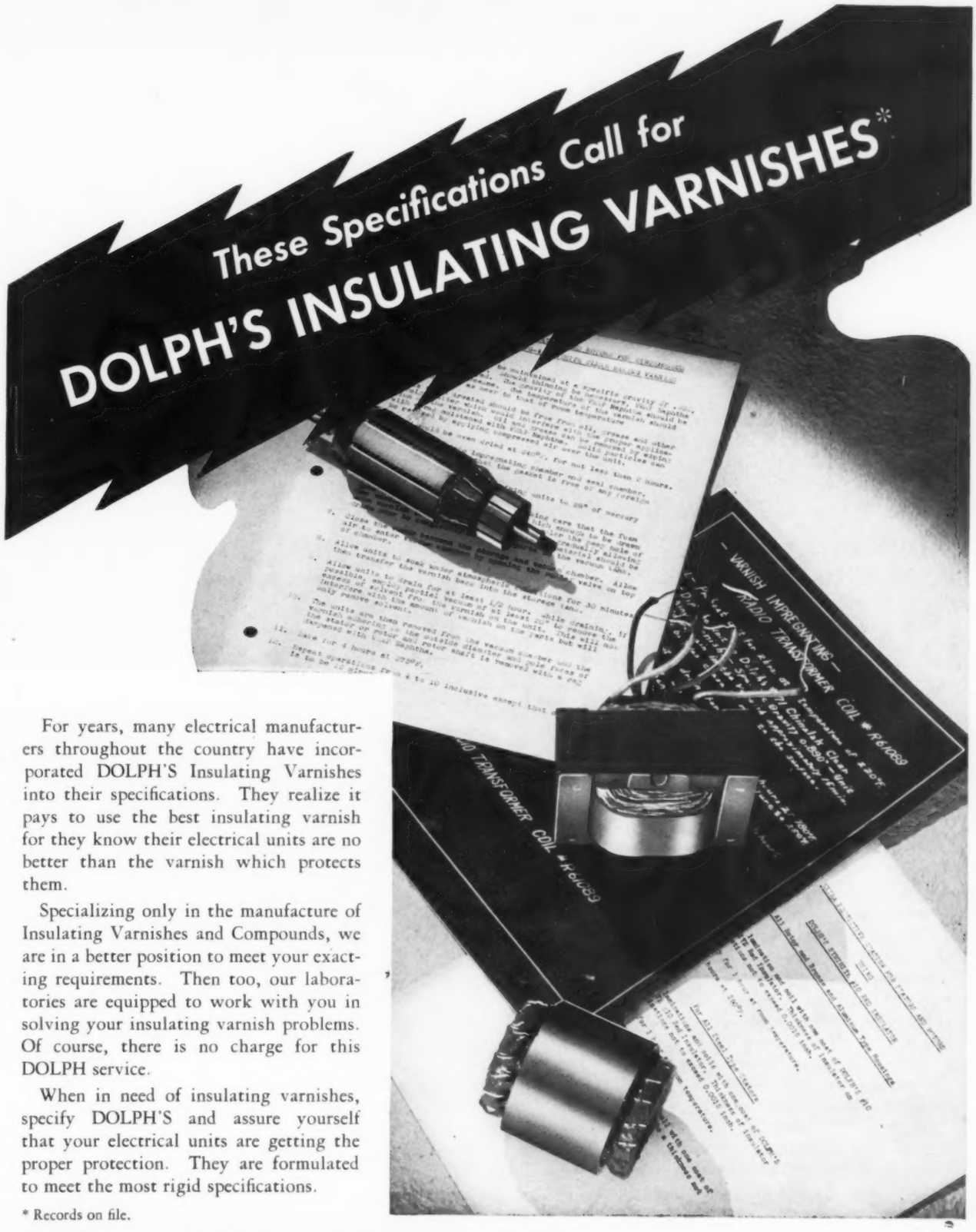

For years, many electrical manufacturers throughout the country have incorporated DOLPH'S Insulating Varnishes into their specifications. They realize it pays to use the best insulating varnish for they know their electrical units are no better than the varnish which protects them.

Specializing only in the manufacture of Insulating Varnishes and Compounds, we are in a better position to meet your exacting requirements. Then too, our laboratories are equipped to work with you in solving your insulating varnish problems. Of course, there is no charge for this DOLPH service.

When in need of insulating varnishes, specify DOLPH'S and assure yourself that your electrical units are getting the proper protection. They are formulated to meet the most rigid specifications.

* Records on file.

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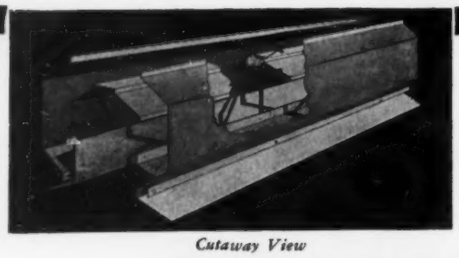
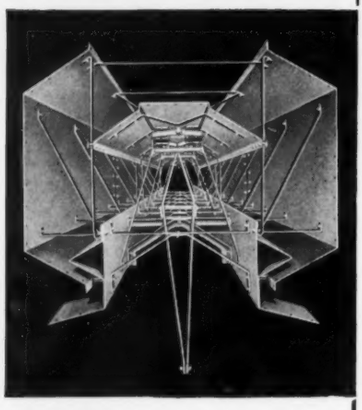
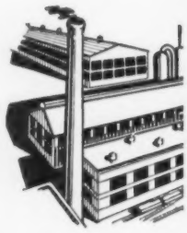


Cutaway View





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Continuous Ridge VENTILATORS

Fresh, live air will increase production in *your* plant. Workmen *stay* alert when your mill is equipped with BURT Monovent Continuous Ridge Ventilators. You get more production with less spoilage and fewer accidents.

Monovent is particularly designed to exhaust large volumes of hot, fume-laden air over the entire length of your buildings. It costs less than unit ventilators of the same capacity — looks better — is storm-proof, no back drafts — will not clog with soot and cinders and is of sturdy construction with no moving parts to get out of order.

Burt makes 3 types of ventilators for steel mill installations — the Monovent Continuous Ridge Ventilator shown here, the Free-Flow Fan and Free-Flow Gravity Ventilators. One of them will best serve your mill. Send — now — for data sheets and job references.

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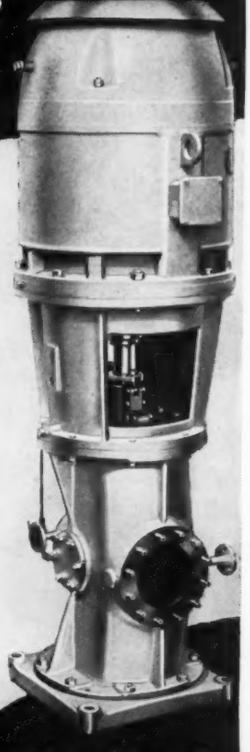

The De Laval-IMO Pump is of the rotary displacement class, but has:

- Only 3 working parts,
- No valves,
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- Only one packing box (on the suction side),
- Perfect hydraulic balance,
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- Freedom from pulsation,
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- Ability to pump any oil in any volume against any pressure.

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May Help His Fighting

When you take a few minutes to glance through a Bristol Bulletin . . . then write for further facts about Bristol's instrument-engineering in *your* industry . . . you may be taking the first step towards solution of one or more of the fundamental problems facing your plant today. Such problems as these, for instance, have often been solved by a wider, more efficient use of Bristol's automatic controls:—*1. Lack of skilled men . . . 2. Shortage of raw materials . . . 3. Need to increase output without increasing space or equipment. . . . 4. Unnecessary spoilage and rejects . . . 5. Errors in putting new products into production.*

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Automatic timing of mechanical operations in industrial processes received its initial impetus when the Bristol Automatic Time-Cycle Controller was developed. Continuous improvements have been made through the years.

Here, in one concise 20-page bulletin, is a complete outline of this "template for efficient operation" — the mechanical operations you can control with it — the results in terms of quality, cost and increased production — details on its operation — and case studies illustrating its application to a wide variety of processes.

Bulletin 572 may point *your* way to a greater production efficiency than you have hitherto imagined possible. Write for it, together with any other bulletins described in the coupon.

THE BRISTOL COMPANY, Waterbury, Connecticut

The Bristol Co. of Canada, Ltd. Toronto, Ontario

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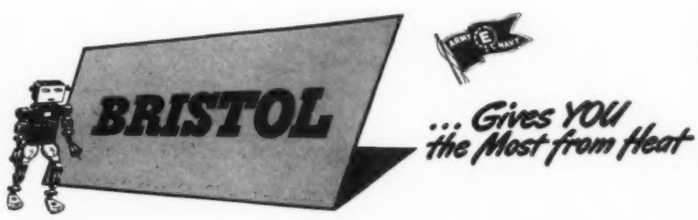

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Control of checker temperatures, and their coordination with furnace reversals formerly consumed a valuable man's time and was apt to delay production through error. Complete automatic reversal of the furnace is now accomplished by Bristol's Cycle Controller governed by a checker-temperature controller, freeing manpower to increase production elsewhere, and insuring a larger, because more uniform, output.

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☐ Bristol's complete manual of instruments for industrial furnaces, kilns and ovens. The most necessary instruments — pyrometers, thermometer controllers, draft controllers, thermocouples, control valves, and many accessories — described with installation and performance facts for all types of fuel.

☐ Bulletin 536 — Describes modern pH control instruments for a wide variety of processes requiring hydrogen ion measurement and automatic control; includes installation data, new glass electrode assembly and list of applications.

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Eliminates Manual Balancing

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The new Brown Electronic "Self-balancing" Precision Indicator reads the correct temperature instantly when the operator throws the proper key switch.

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MATERIALS HANDLING *Short Cut*

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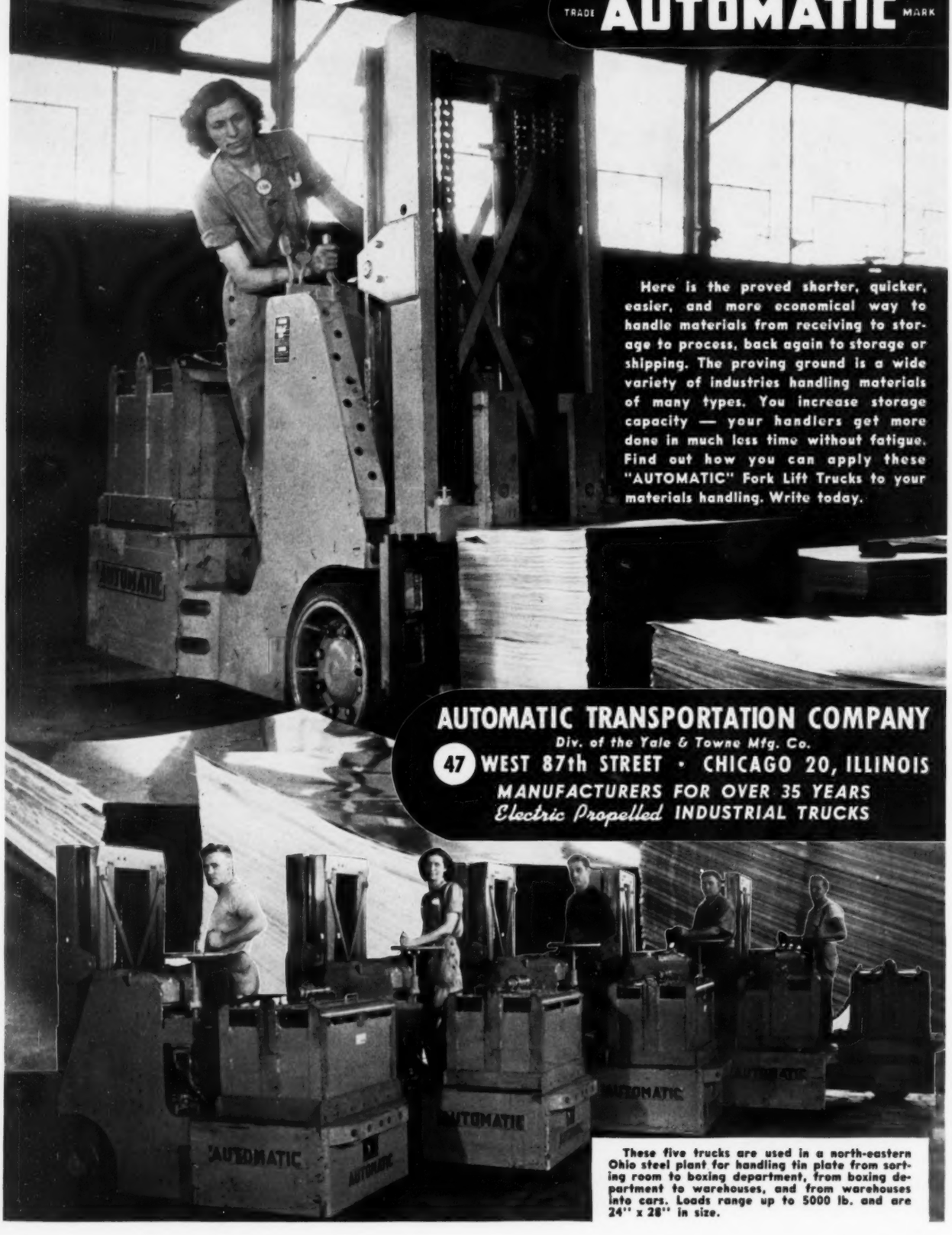

Here is the proved shorter, quicker, easier, and more economical way to handle materials from receiving to storage to process, back again to storage or shipping. The proving ground is a wide variety of industries handling materials of many types. You increase storage capacity — your handlers get more done in much less time without fatigue. Find out how you can apply these "AUTOMATIC" Fork Lift Trucks to your materials handling. Write today.

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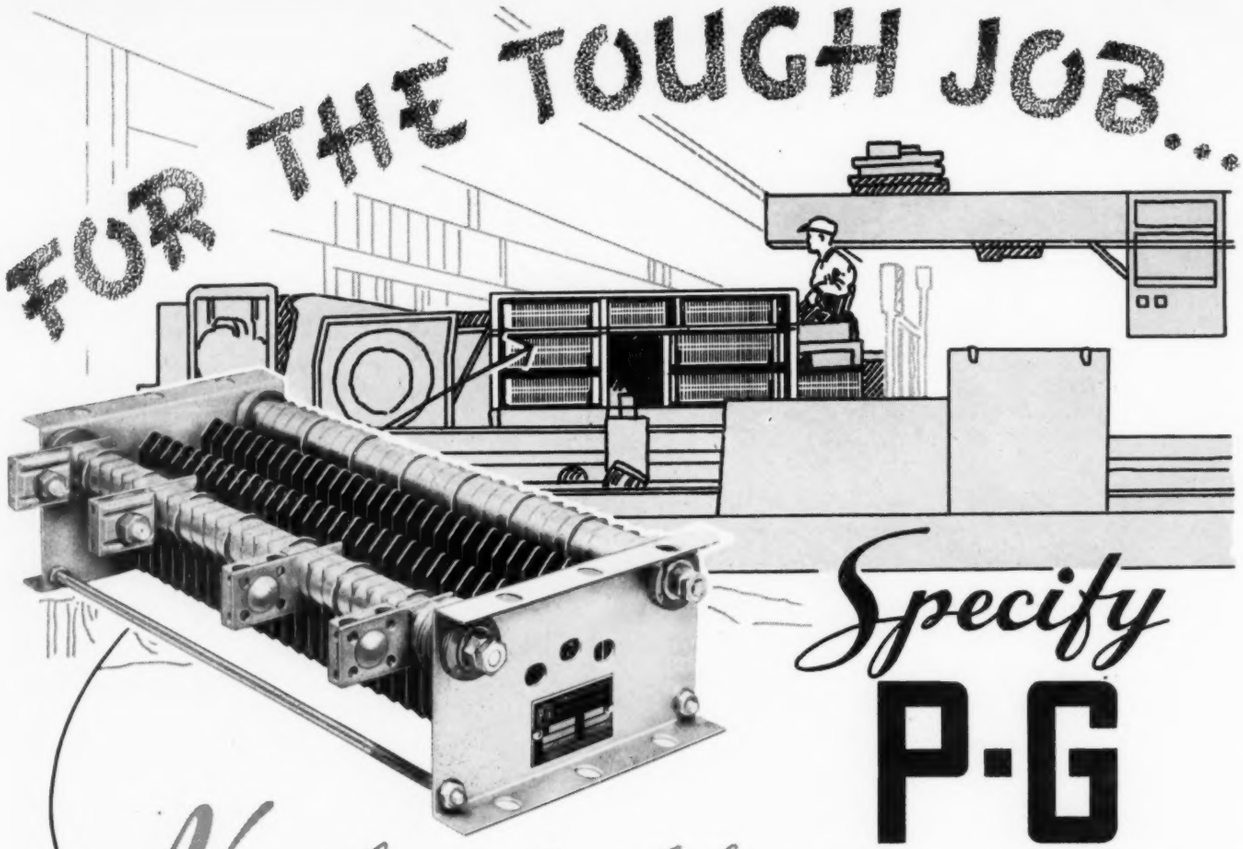

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"The Resistor you can Install and Forget"

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

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KC CIRCUIT BREAKERS

AUTOMATIC RECLOSING CIRCUIT BREAKERS

RM CIRCUIT BREAKERS

KLAMP-TITE SWITCHES

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Type MT circuit breakers are used in steel mill d-c systems for protection of generators, motors and heavy feeders where extremely heavy fault currents are to be expected and "semi-high speed" current interruption is adequate. Interrupting time is about 1¾ cycles (60 cycle basis).

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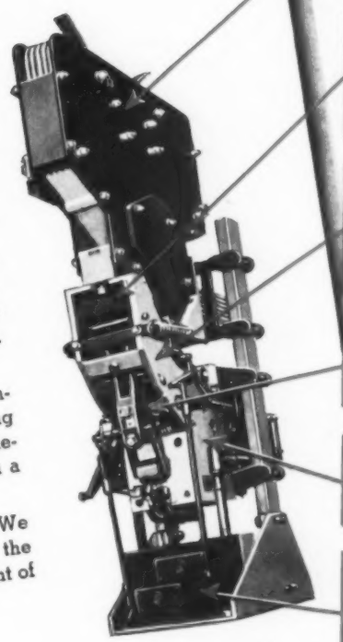
Catalog 2201 describes the Type MT circuit breaker in detail. We will send you a copy, or I-T-E engineers will gladly discuss the Type MT or other steel-mill equipment in the I-T-E line in the light of conditions in *your* mill.



MAGNETIC ARC CHUTE of large thermal capacity draws gas and arc upward for safe extinction. Inductive recovery voltage is kept to low peaks. Arcing time is extremely short with either light or heavy currents.

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AIR SWITCHGEAR

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How induction-furnace power *is accurately controlled by the* AMPLIDYNE

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Used as exciters on many high-frequency generators, amplidynes hold voltage within extremely narrow limits. By their ***forcing*** action, amplidynes speed up the otherwise slow response of the heavy generators. Thus they quickly correct for wide load swings resulting from the changing resistance of the charge.

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Applied to high-frequency generators used in coreless melting, surface hardening, and heating for forging, as well as to many other types of steel-mill equipment, G-E amplidynes are revolutionizing automatic control. G-E engineers will gladly discuss the details with you. ***General Electric Company, Schenectady, New York.***

SEND FOR YOUR COPY of "The Short Circuit That Moves Mountains." Thirty-six pages showing how G-E engineers, in designing the amplidyne, utilized a short circuit, together with load-current compensation, to produce a generator-type amplifier of almost instant responsiveness and having amplification factors ranging up to 10,000 to 1. Ask for Bulletin GEA-4055.

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